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"CONFIDENTIAL—MODIFIED HANDLING AUTHORIZED"

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-380

This manual supersedes TM 11-380, 17 March 1944

CONVERTER M-209

M-209-A, M-209-B

(CIPHER)

WAR DEPARTMENT *MAY 1947*

~~"CONFIDENTIAL—MODIFIED HANDLING~~ AUTHORIZED"

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RESTRICTED

WAR DEPARTMENT
Washington 25, D. C., 16 May 1947

TM 11-380, Converter M-209, M-209-A, M-209-B (Cipher), is published for the information and guidance of all concerned.

[AG 300.7 (31 Oct 46)]

BY ORDER OF THE SECRETARY OF WAR:

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Chief of Staff

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Major General
The Adjutant General

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(2); 1–167R (2); 1–267 (2); 1–297 (2); 1–298 (2); 1–299 (2); 1–312 (2); 1–312R (2); 1–317 (2); 1–317R (2); 1–452R (2); 1–452T (2); 1–457R (2); 1–457T (2); 1–487 (2); 1–547 (2); 1–562R (2); 1–567R (2); 1–600, Teams AB, AD, AE, CB, FD, FF, FI, GB, RC, RD, RE (2); 1–627, Wea Sta Type A, B, C, D, R, W, Z (2); 1–752 (2); 1–757 (2); 1–778 (2); 1–987 (2); 1–1037 (2); 2–22 (3); 2–26 (3); 2–27 (3); 5–16 (3); 5–192 (3); 5–216 (3); 5–217 (3); 5–226T (3); 5–416 (3); 5–512T (3); 5–516T (3); 5–627 (3); 6–10–1 (3); 6–12 (3); 6–26 (3); 6–36 (3); 6–56 (3); 6–166 (3); 6–167 (3); 6–169 (3); 6–200–1T (3); 6–216T (3); 6–226T (3); 7–12 (3); 7–16 (3); 7–26 (3); 7–29 (3); 7–52T (3); 7–56T (3); 8–76 (3); 9–66 (3); 9–67 (3); 10–37 (3); 11–15 (5); 11–25 (5); 11–57 (3); 11–95 (5); 11–107 (3); 11–127 (3); 11–147S (3); 11–337 (3); 11–338 (3); 11–537T (3); 11–557T (3); 11–587 (3); 11–597 (3); 17–2 (3); 17–17 (3); 17–20–1 (3); 17–22 (3); 17–26 (3); 17–29 (3); 17–60–1 (3); 18–26 (3); 19–56 (3); 19–57 (3); 44–10–1 (3); 44–12 (3); 44–16 (3); 44–26 (3); 44–76 (3); 44–116 (3); 44–126 (3); 44–136 (3).

For explanation of distribution formula, see TM 38–405.

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DESTRUCTION NOTICE

WHY —To prevent an enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander or when capture is imminent.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, heel of a boot, etc.

2. Cut—Use axes, handaxes, machetes, etc.

3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades, etc.

4. Explosives—Use firearms, grenades, TNT, etc.

5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

PRELIMINARY—1. Move all drum-bar lugs to zero positions.

2. Move all rotor pins to left positions.

WHAT—1. Smash—Drum bars, rotors, guide arms, type wheel, gears, levers.

2. Cut—Canvas case, straps.

3. Burn—Cipher keys, technical manuals, paper tape, canvas case.

4. Bury or scatter—Any or all of the above pieces after breaking.

DESTROY EVERYTHING

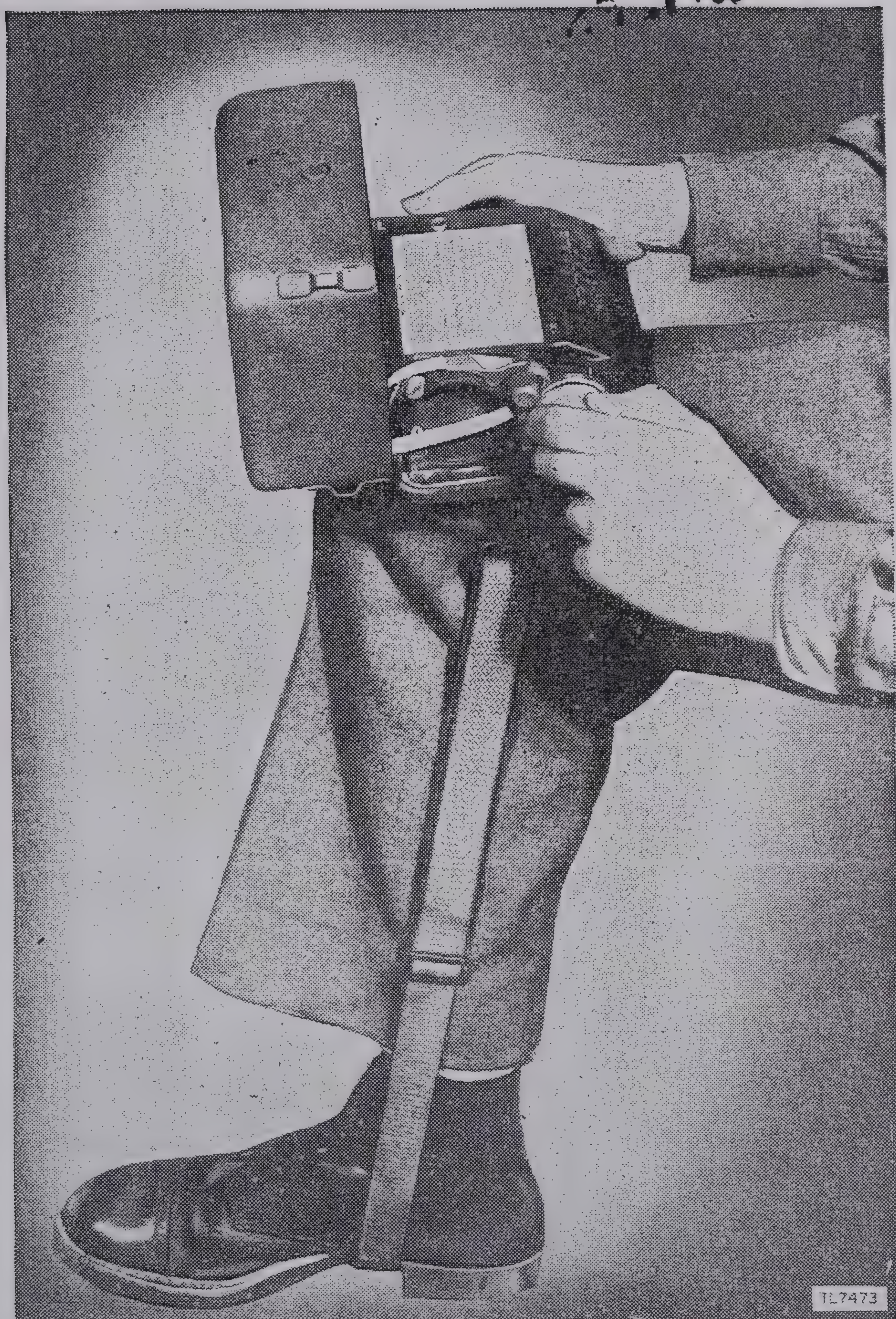

Figure 1. Converter M–209–(*) in use.

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This manual supersedes TM 11–380, 17 March 1944

CHAPTER ONE

INTRODUCTION

Section I. DESCRIPTION

1. Scope

a. This Technical Manual covers the description, operation, maintenance, repair, and emergency destruction of Converter M–209–(*). The manual sets forth detailed instructions on the prescribed method of concealing the message rotor alinement (internal message indicator)† used to encipher a message. It also includes a list of security precautions to be observed when Converter M–209–(*) is used. Information on preparation of cipher keys for use with the converter is given in the appendixes.

b. Converter M–209–(*) represents Converters M–209, M–209–A, and M–209–B, which are treated together throughout this manual.

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† Certain new terms are used throughout this manual. In each instance where a new term is used for the first time, it is followed by the old term in parentheses.

2. General

a. Converter M–209–(*) is a small compact, hand-operated, tape-printing, mechanical cipher machine. When properly set and operated, it will encipher a plain-text message by substituting a letter for a letter, automatically printing the enciphered text on a paper tape in five-letter groups; or it will decipher a message that has been previously enciphered by a Converter M–209–(*), printing the clear text on the paper tape.

b. The converter is contained in a metal box, and is normally carried in a canvas case, suspended by a strap over the shoulder. The case has compartments for carrying the manual, pencils, extra tape, message books, and message clips. Inside the cover of the converter are clamps for holding a screw driver, a pair of tweezers, an oilcan, an ink-pad can, and the roll of paper tape in use. When desired, a hand-carrying strap may be attached to the left side of the machine.

3. Application of Converter M–209–(*)

a. Converter M–209–(*) provides a high degree of security, but *only* when operators are fully indoctrinated in the necessity for strict compliance with each rule for enciphering and when messages are prepared with a proper regard for security. Dangers to the system are as follows:

(1) An operator may commit the error of using a message indicator (external indicator) (par. 23) which has already been used on another message. When this occurs, the two messages bearing the same indicator may be read by the enemy, probably within 1 to 2 hours, other messages in the same key may be read within a few hours thereafter, and in all probability all the traffic enciphered in that key may be read within 2 to 3 days. (It should be noted that the chance of two identical indicators being used when indicators are chosen at random is so remote that it can be disregarded.)

(2) An operator, when re-enciphering a message for service, may commit the error of using the same message indicator as used for the first encipherment of the message. In such a case, the message usually can be read by the enemy, and other messages in the same key may be read. Time for reading these is approximately the same as in (1) above.

(3) A stereotyped phrase or statement may be used so regularly in some special type of message, particularly at the beginning or end, as to come to be expected from one day to the next or from one week to the next. Or the same message may even be enciphered in identical wording from one day to another, as for example a negative report. While stereotypes will continue to be a constant hazard to the security of Converter M–209–(*), the use of variable spacing between words (par. 26*b*(4)) will

reduce the danger which they present. When spacing between words is always regular, the exact lettering of stereotypes may be known; in such cases the entire message may sometimes be read by the enemy, and then further traffic in the same key may be read approximately as in (1) above. When spacing is varied as prescribed in paragraph 26*b*(4), the exact lettering is not known; therefore the time required for reading traffic on the basis of a stereotyped phrase or statement will usually be lengthened by as much as 24 to 48 hours.

b. The above faults *do* occur in Converter M–209–(*) traffic. Where operators with little training are used, the more immediate danger usually is from the faults explained in subparagraphs *a* (1) and (2) above. They may be eliminated *only* by a check at a central headquarters on all traffic which has been enciphered, the check to include the comparison of message indicators used on all messages and a study of the actual plain text to determine whether dangerous stereotypes exist. If such precautions are taken, faults eliminated, and all instructions in this manual are followed, it is almost a certainty that Converter M–209–(*) messages will resist enemy cryptanalysis for weeks if not indefinitely.

c. Converter M–209–(*) will never be used for SECRET traffic except when a system normally authorized for SECRET traffic is not available. When a SECRET message must be enciphered by

means of Converter M–209–(*), the CONFIDENTIAL key will be used and the word SECRET, set off by two X's on each side, will be buried in the text before encrypting.

d. Converter M–209–(*) will not be used for CONFIDENTIAL traffic above the level of corps or comparable organization except as authorized by the Army Security Agency of the theater or the War Department.

e. Instructions in this manual are applicable to all cipher systems using Converter M–209–(*).

4. Cryptosystems (Cryptographic Systems)

a. DEFINITION. A military cryptosystem comprises a prearranged set of rules and aids chosen for encrypting messages sent from one unit to another. All systems fall into one of two classifications, *code* or *cipher*. In code systems, groups of letters or numbers represent letters, numbers, words, phrases, or entire sentences. A cipher system normally uses single letters to represent other single letters. Converter M–209–(*) is a cipher machine since, when operated, it substitutes a letter for a letter.

b. KEY LIST. Every cipher system must be provided with a guide, or *key list*, for its operation. The key list should be changed as often as necessary to preserve the security of the system. The key list for a system using Converter M–209–(*) consists of a

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pin and lug setting published in a system publication or the Signal Operation Instructions (SOI) of the using unit. This key governs preliminary settings which must be made before enciphering or deciphering messages. The proper use of the key list is explained in paragraphs 16 through 19.

c. CONVERTER M–209–(*) SYSTEMS. Any cipher system using the Converter M–209–(*) must consist of the following:

(1) Converter M–209–(*).

(2) This manual, which contains operating instructions for Converter M–209–(*).

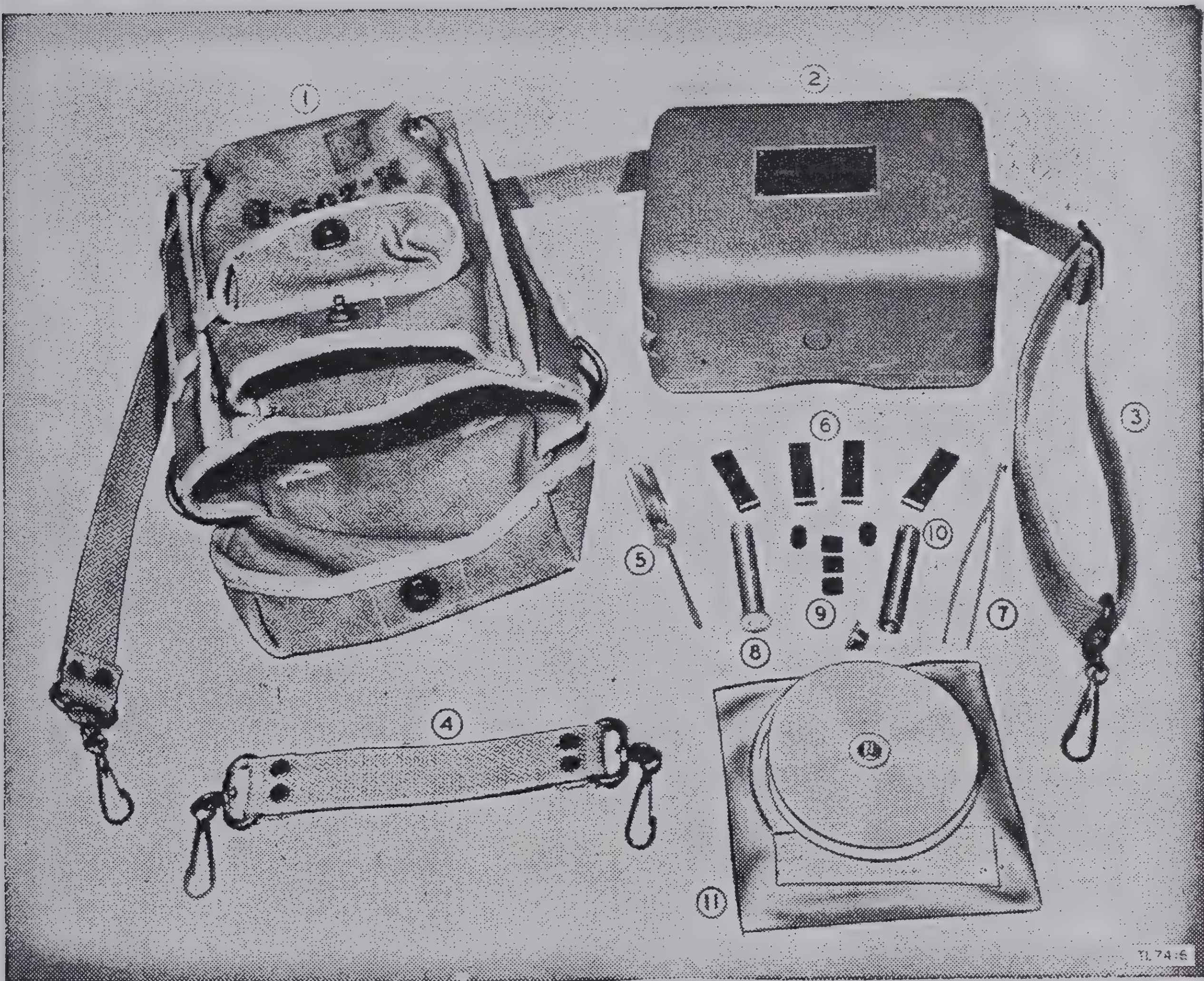
(3) The pin and lug setting in effect at the time.

5. Table of Components

Component	Dimensions (in.)	Weight (lb.)
Converter M–209–(*)	$7\frac{1}{4} \times 5\frac{7}{16} \times 3\frac{1}{2}$	6
Case, canvas (complete with straps)	$8\frac{1}{4} \times 6\frac{1}{2} \times 6$	1
Strap, hand-carrying (complete with snaps)	$11\frac{5}{8}$ long	

6. Accessories

The following accessories are issued with the converter and provision is made for carrying them in the canvas case and the outer cover of the converter (par. 2*b*.)



1. Canvas case (6E1009A/C5).
2. Converter M–209–(*) (6E1009(*)).
3. Carrying strap.
4. Hand strap (6E1009A/S75).
5. Screw driver (6E1009A/S25).
6. Message clips (6E1009A/C12).
7. Tweezers (6E1009A/T5).
8. Oilcan (6E1009A/C2).
9. Ink pads (6E1009A/P25).
10. Ink-pad can (6E1009A/C1).
11. Paper tape, ungummed (4A2708); gummed (4A2701.2).

Figure 2. Components and accessories.

Quantity	Accessories	Dimensions (in.)
1	Oil can	$2\frac{5}{16}$ x $\frac{3}{8}$
1	Ink-pad can	$2\frac{5}{16}$ x $\frac{3}{8}$
1	Screw driver	4 long ($2\frac{3}{16}$ blade, $\frac{3}{16}$ tip)
1 pr.	Tweezers	4 long
2 rolls	Paper tape	4 diam, $\frac{3}{8}$ wide
5	Ink pads	
4	Message clips	
2	TM 11–380	$4\frac{1}{4}$ x 6

7. Packaging Information (figs. 5 and 6)

a. The total weight of Converter M–209–(*), including accessories, is approximately $7\frac{1}{4}$ pounds.

b. Each converter, with its components and accessories, is enclosed in a unit package. This package consists of an outer corrugated fiberboard box, a moisture-vaporproof barrier, an inner corrugated fiberboard box, a tray for the silica gel, a liner to go around the converter, and a half-box for the canvas carrying case and the message books (par. 60). The unit package weighs about 10 pounds when packed for shipment and has a volume of 0.37 cubic feet.

c. Four unit packages are packed together in one fiberboard shipping container for shipment to points in this country.

d. For oversea shipments, four unit packages are placed in a wooden shipping container. A liner bag of waterproof paper inside this container protects the units from moisture (fig. 5).

8. Indentification of Parts

a. PRELIMINARY PROCEDURE. Open the outer cover of the machine by pushing the button located in the center of the front of the cover. Raise the inner lid from the front by lifting it off its spring catch.

b. NUMBERED REFERENCE LIST. Operators of Converter M–209–(*) can identify all the parts of the

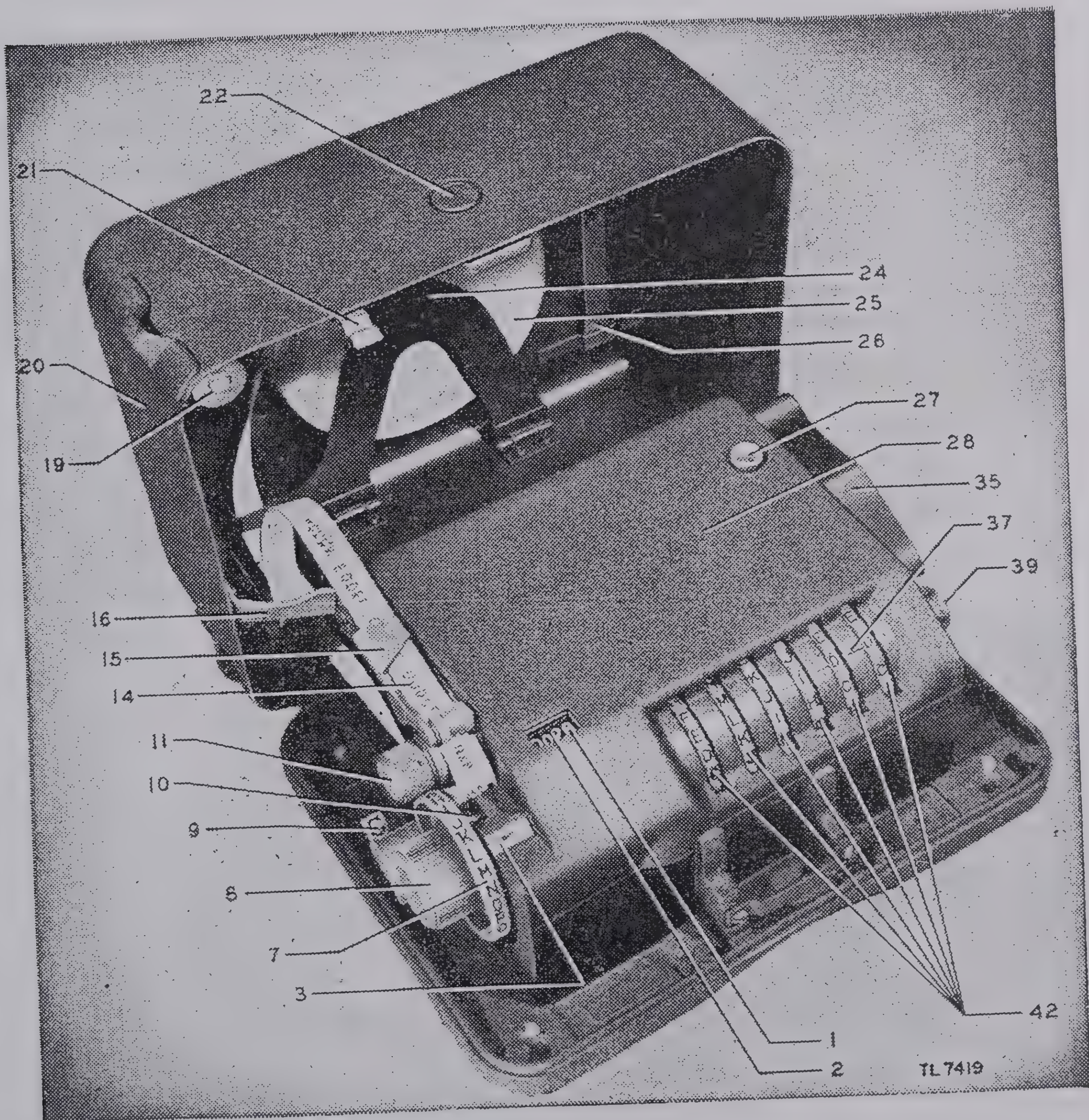


Figure 3. Converter M–209–(*) open for operation.

(1) Letter-counter window.
(2) Letter counter.
(3) Indicating index.
(4) Ink pad.
(5) Type wheel.
(6) Reproducing disk.
(7) Indicating disk.
(8) Setting knob.
(9) Encipher-decipher knob.
(10) Reading window.
(11) Paper-feed knob.
(12) Paper-feed ratchet.
(13) Five-letter cam.
(14) Paper tape.
(15) Paper-pressure arm.
(16) Cover support.
(17) Ink-pad can.
(18) Screw driver.
(19) Oilcan.
(20) Outer cover.
(21) Catch for inner lid.
(22) Cover-catch button.
(23) Paper-guard catch.
(24) Paper guard.
(25) Paper roll.
(26) Tweezers.
(27) Reset button.
(28) Inner lid.
(29) Number plate.
(30) Drum disks.
(31) Drum bar.
(32) Drum-bar lug.
(33) Intermediate-gear release arm.
(34) Guide arm.
(35) Drive knob.
(36) Intermediate gear.
(37) Rotor bench mark.
(38) Rotor gear.
(39) Reset knob.
(40) Noneffective pin.
(41) Effective pin.
(42) Rotors.
(43) Type-wheel gear.

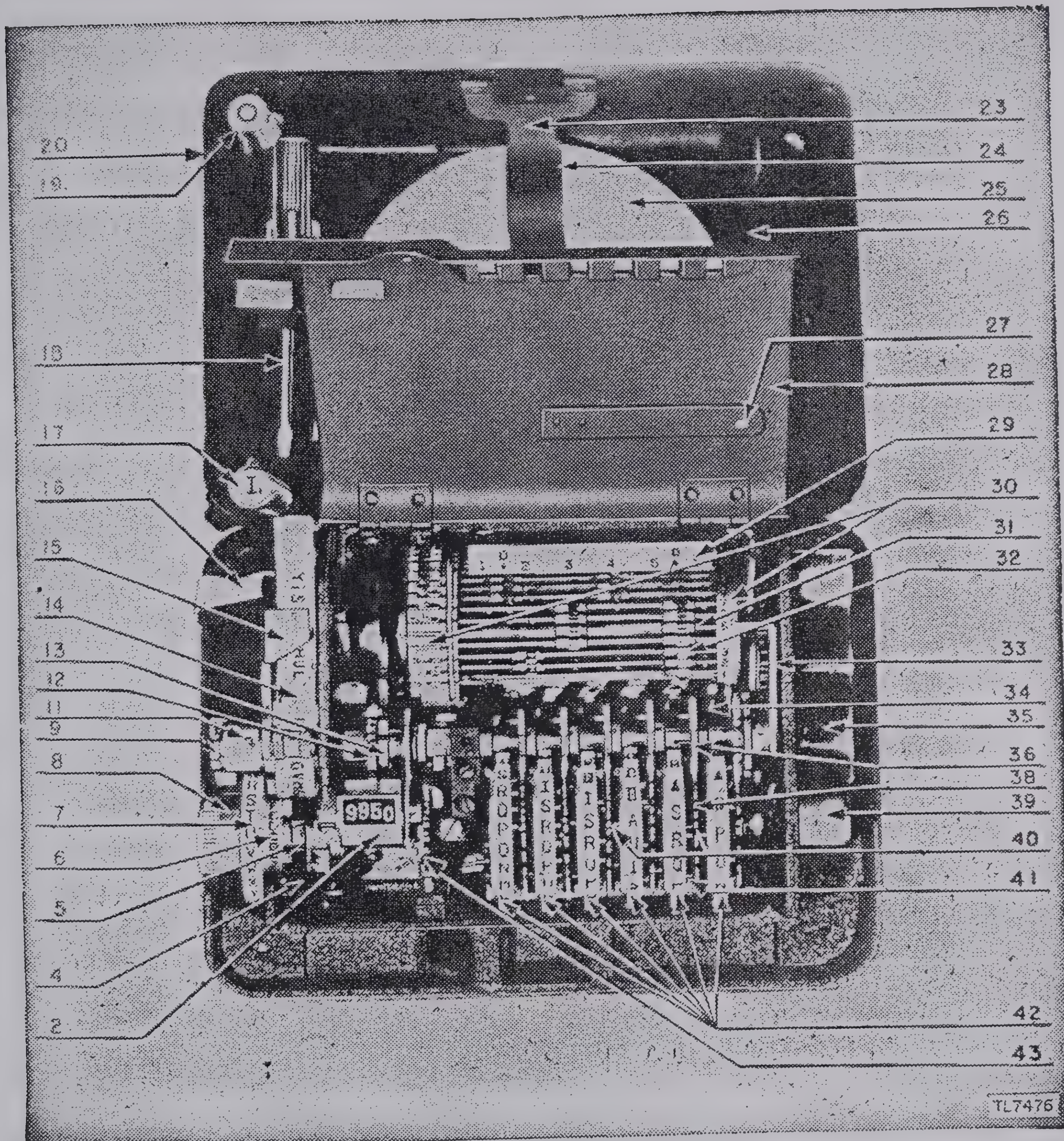


Figure 4. Inside view of Converter M–209–(*).

device by referring to the list on page 10 and figures 3 and 4. Numbers in parentheses such as (10) correspond to those in figures 3 and 4, and should be studied with an opened converter near by so that each part may be located. These numbers will be used throughout this manual to assist in identifying parts.

9. Principal Operating Parts

a. ROTORS (KEY WHEELS) (42). (1) Letters of the alphabet in reverse order are engraved on the rims of the six rotors. On each rotor, from left to right, there is a decreasing number of letters. The letters are arranged on the rotors as follows:

Rotor No.	*No. of letters*	*Letters*
1	26	A–Z
2	25	A–Z, omitting W
3	23	A–X, omitting W
4	21	A–U
5	19	A–S
6	17	A–Q

(2) Near the rim of the rotors, and just beneath each letter, a small pin projects from one side or the other of the rotors. The *rotor pins* may be pushed from side to side in the slots in which they are set. The letters and pins are arranged as part of the preliminary setting of the machine and are explained in detail in paragraph 18. The rotors are mounted on a shaft, on the right end of which is the *reset knob* (39). The rotors may be turned as a unit in either direction when the *reset button* (27) is depressed and the reset knob rotated. Individual rotors may be turned by hand in one direction only.

b. INDICATING DISK (7). The indicating disk is the larger of two disks located on the left-hand side of the converter. Letters of the alphabet are ar-

ranged on its rim in normal order. The disk can be rotated freely in either direction, allowing any letter to be alined on a white bench mark, called the *indicating index* (3). The large knob on the left of the indicating disk is used for turning the disk to the desired letter.

c. REPRODUCING DISK (6). The letters of the alphabet are engraved in reverse order upon the reproducing disk, the smaller disk located just to the right of and on the same shaft as the indicating disk. When the inner lid is closed, four of the letters can be seen through the *reading window* (10) on the edge of the inner lid. The first letter, nearest the front of the machine, is read when this disk is used (pars. 26*a*(9) and 65*b*).

d. TYPE WHEEL (5). The type wheel is mounted on the same shaft with the two disks mentioned above. On its rim are raised letters for printing. These letters are also in reverse order. The last letter printed and the letter which is read on the reproducing disk are the same.

e. PAPER-FEED KNOB (11). The paper tape is advanced automatically when the converter is operated, and also can be fed through the rollers by turning the paper-feed knob. The knob turns toward the rear of the machine only.

f. PAPER-PRESSURE ARM (15). On the front end of the paper-pressure arm is a small, knurled roller which is held firmly against a larger roller by spring

tension. To raise the roller, push down on the rear end of the pressure arm. The roller and arm are used to guide the paper tape. A *cutting edge* is provided on the end of the pressure arm to facilitate tearing off the tape.

g. LETTER COUNTER (2). The letter counter is visible through a window in the left front corner of the converter. It counts letters enciphered or deciphered up to 9999. The counter is returned to zero by turning the *reset knob* (39) in either direction while depressing the *reset button* (27) on top of the inner lid.

h. ENCIPHER-DECIPHER KNOB (9). Just below the paper-feed knob is the encipher-decipher knob. When turned to the "C" position, the converter is set for enciphering clear text; when set in "D" position, it is ready to decipher encrypted text. The position of this knob should be checked before operation.

i. DRIVE KNOB (35). The large black operating handle on the right-hand side of the machine is the drive knob. Each time the indicating disk is moved, the drive knob may be turned once and then locks. At each turn of the drive knob, the machine enciphers or deciphers a letter and prints the equivalent letter on the tape.

j. DRUM. When the inner lid is open, the drum can be seen at the rear of the machine. On the drum are 27 *drum bars* (31), which occupy about two-thirds

of the circumference of the drum and are numbered at the right of the drum. On each drum bar are two movable lugs which may be set in any one of eight positions, numbered 1⧬2345⧬6. Each lug fits into a small hole at each position. It must be pushed slightly toward the front of the machine before it can be disengaged from one hole and slid along the bar into another. When placed at any position, *the lug must always be fitted into the hole provided for it.*

10. Canvas Carrying Case

A khaki-colored, heavy canvas carrying case is provided for protecting the converter from dust and moisture when it is not in use. A **D**-ring is attached at each end of a web strap, which is sewed to the canvas carrying case. An adjustable web strap, with a swiveled snap on each end, fastens to the **D**-rings and provides a convenient means of slinging the converter from the shoulder. A pocket with a snap fastener, on the front of the carrying case, provides space for carrying message clips. On the back of this pocket is a second pocket in which the technical manual, message books, and extra tape may be carried. A small patch pocket on one side of the carrying case is provided for pencils. The top flap of the case folds over the converter in the case and the manual and message-book pocket. A snap fas-

tener holds the cover down. Two web loops on the back of the case may be used to suspend the case from the operator's belt if desired.

11. Differences in Models

Three models of Converter M–209–(*) have been produced, namely, Converters M–209, M–209–A, and M–209–B. Converter M–209 was given a very limited distribution to the field. Converter M–209–A and Converter M–209–B differ in the material used for the *indicating disk* (7), *reproducing disk* (6), and *setting knob* (8). The indicating and reproducing disks and setting knob of Converter M–209–A are made of metal; these parts are of plastic on Converter M–209–B. The indicating and reproducing disks and the setting knob are part of the *type-wheel assembly*. (These differences hold true for most converters which have been issued, but do not affect the interchangeability of parts involved.)

Section II. INSTALLATION AND ASSEMBLY

12. Location

Converter M–209–(*) can be operated in any location. Usually the converter is set up on a table or other solid support. If necessary, the machine may be secured to the operator's knee, as shown in figure 1. Attach the carrying strap to the bottom of

the converter and pass it under the operator's foot. Shorten or lengthen the strap so that the converter will be held firmly in place on the knee. The base of the machine is shaped to fit the curvature of the knee. Normally, Converter M–209–(*) is operated under cover to protect it from dust and moisture. If tactical situations require operation of the converter out-of-doors, see that the machine is protected from moisture and dust as much as possible during operation. Return the converter to its canvas carrying case after use out-of-doors.

13. Unpacking and Checking Equipment

a. Oversea Shipping Container. Remove the four converters which are packed in the wooden shipping container as follows:

(1) Remove the two metal straps (fig. 5).

(2) Pull the nails from the lid of the wooden box and remove the cover.

(3) Open the waterproof-paper liner and remove the four unit packages.

b. Domestic Shipping Container. Open the fiberboard shipping container and remove the unit packages.

c. Unit Package. (1) Loosen and pull off the three strips of paper tape which seal the seams of the outer corrugated fiberboard box, shown packed in the oversea shipping container in figure 5.

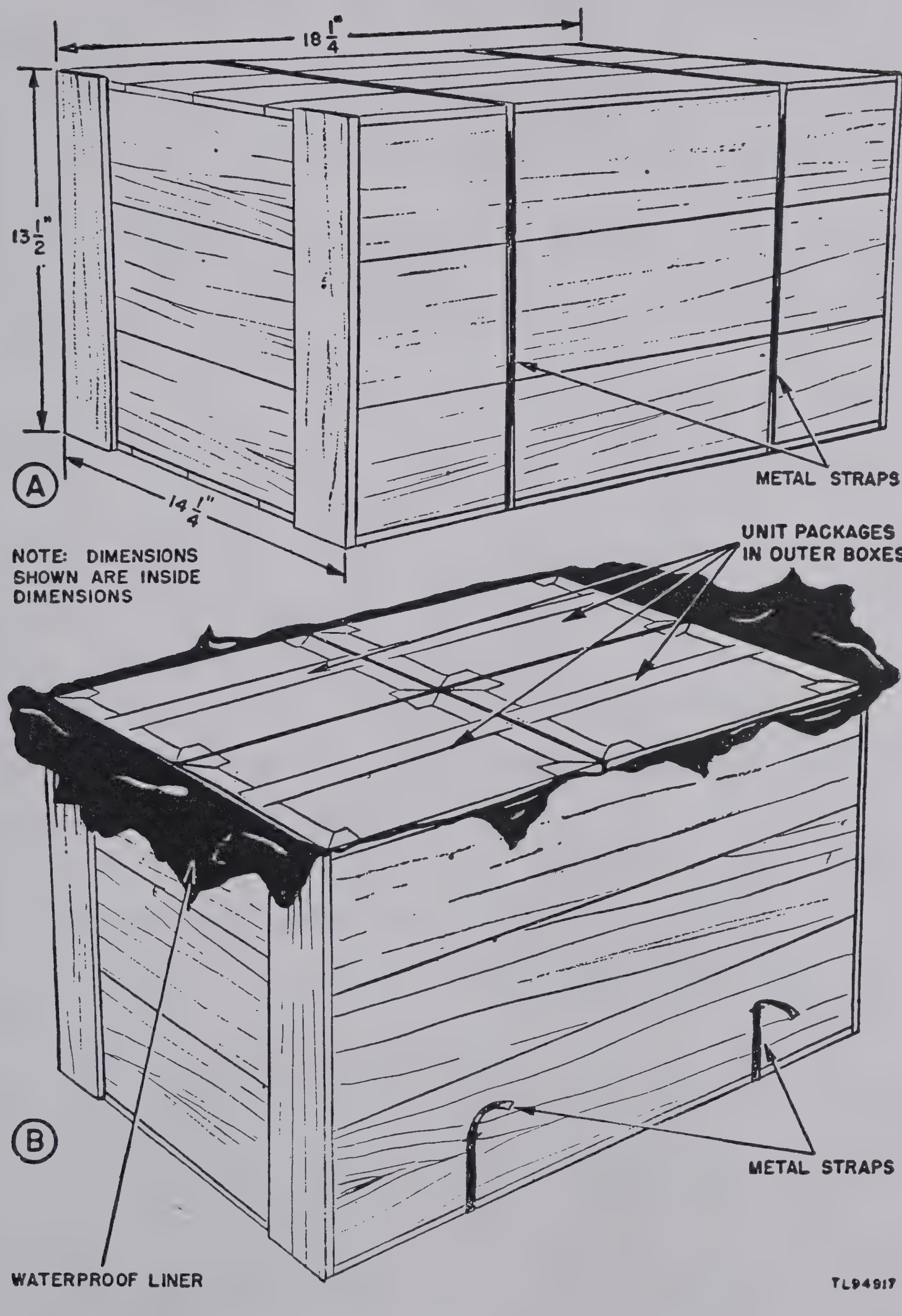


Figure 5. Oversea shipping container.

(2) Remove the moisture-vaporproof barrier (fig. 6).

(3) Take out the inner corrugated fiberboard box containing the converter with its components and accessories.

(4) Loosen and pull off the three strips of paper tape which seal the seams on top of the inner corrugated fiberboard box.

(5) Open the top flaps of the inner box and remove the silica gel, the fiberboard tray, and the liner.

(6) Remove Converter M–209–(*).

(7) Loosen and pull off the three strips of paper tape which seal the seams of the half box found in the bottom of the inner box.

(8) Open the flaps of the half box and remove the folded canvas carrying case and the two packaged message books.

d. EQUIPMENT CHECK. Check to see that all components and accessories are present.

(1) *In canvas carrying case* (fig. 2). (*a*) Carrying strap (3).

(*b*) Hand strap (4).

(*c*) Two copies of TM 11–380.

(*d*) Spare roll of paper tape (11).

(*e*) Four message clips (6).

(2) *In converter case* (figs. 3 and 4). (*a*) Oilcan (19).

(*b*) Ink-pad can (17).

(*c*) Screw driver (18).

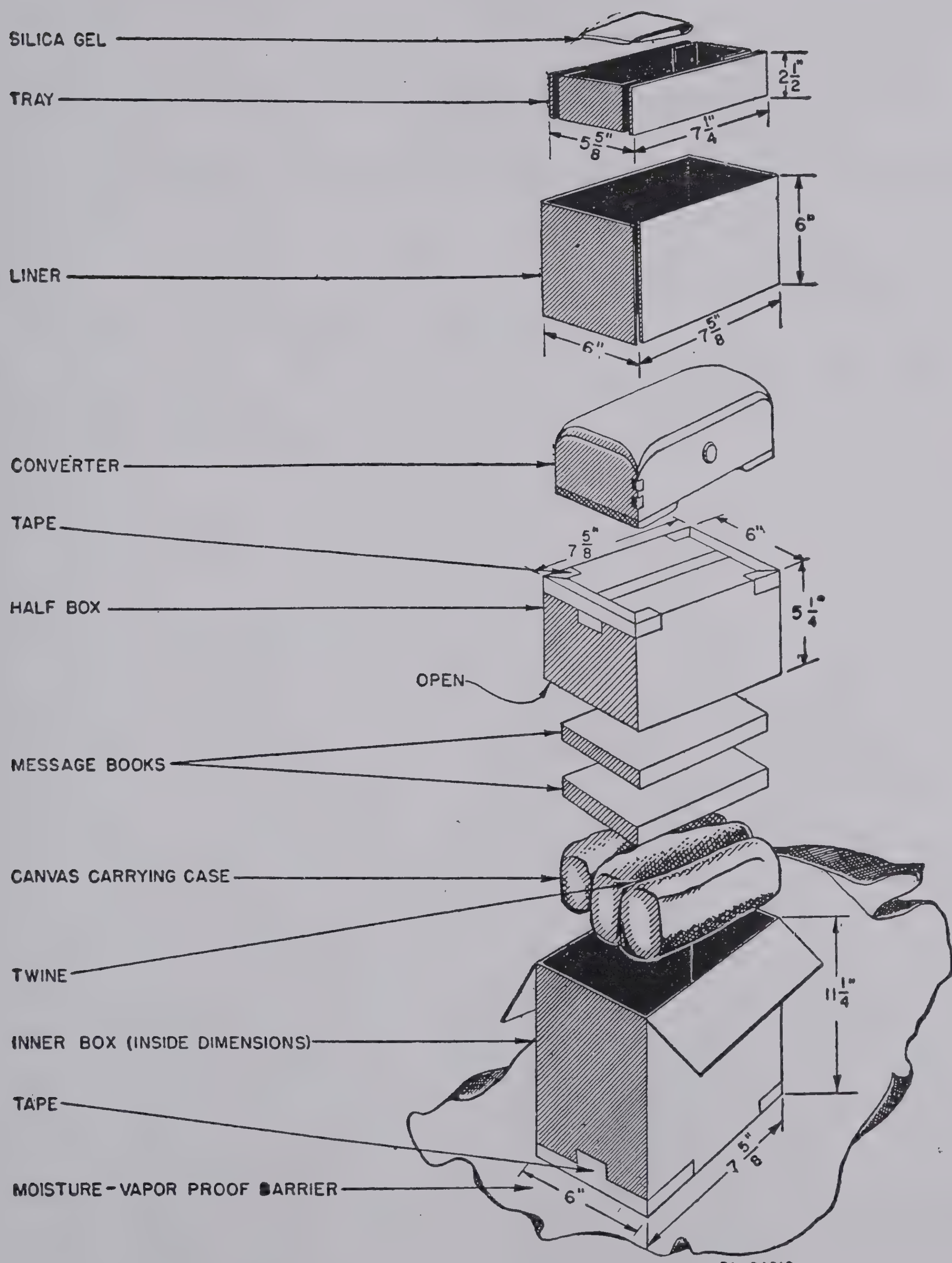


Figure 6. Unpacking procedure.

(*d*) Tweezers (26).
(*e*) Five ink pads (inside ink-pad can).
(*f*) Roll of paper tape (25).

14. Repacking for Troop Movements

a. Check to see that all parts are present (par. 13*d*).

b. Pack the converter in the canvas carrying case and close the snap fastener.

c. Attach the carrying strap to the two **D**-rings on the carrying case.

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CHAPTER TWO

OPERATING INSTRUCTIONS

Note. For information on destroying this equipment to prevent enemy use, see the destruction notice at the front of this manual.

Section III. PRELIMINARY PROCEDURE

15. Operating Position

Place Converter M–209–(*) in operating position, either on a table or on the operator's knee, as described in paragraph 12. Before attempting to encipher or decipher any messages, make the adjustments and checks explained in paragraphs 18, 19, and 20.

16. Keying Elements

Converter M–209–(*) uses two daily keying elements and a message keying element.

a. DAILY KEYING ELEMENTS. (1) The daily keying elements are:

(*a*) Position of the rotor pins (40), (41).

(*b*) Position of the movable lugs (32) on the drum bars (31).

(2) These elements are determined by the pin

and lug setting appearing in the system publication or current Signal Operation Instructions. Instructions for setting the pins and lugs are given in paragraphs 18 and 19.

b. MESSAGE KEYING ELEMENT. The message keying element consists of the six letters used for the initial alinement of the rotors when encipherment or decipherment is begun. This element is termed the *message rotor alinement* (internal message indicator). Paragraph 24 contains instructions for deriving the message rotor alinement from six letters chosen at random by the operator.

17. Change of Keys

A high degree of cryptosecurity can be obtained from Converter M–209–(*); however, experience has shown that when it is necessary occasionally to use new operators with little training, rules for enciphering indicators are not always strictly observed, and traffic may, therefore, be compromised. For this reason and because of other factors, the following precautions will be observed in the provision of keys.

a. During time of war, and under peacetime conditions when units are taking part in simulated tactical operations, and in any situation considered by a commander to warrant the provisions required in tactical operations, the following rules for change and distribution of keys (pin and lug settings) will be observed:

(1) Keys will be changed at least daily.

(2) A separate key will be provided for use by each division and its attached units.

(3) A separate key or separate keys will be provided for use by each corps and its attached units (except within division).

(4) A separate key will be provided for use by any unit smaller than division and operating independently.

(5) Separate keys will be provided in Air Force nets, and any nets not covered above, to the smallest number of holders consistent with efficiency of communications and in such a way that the traffic load in any one key will not normally exceed 10,000 groups.

b. Under peacetime conditions except as provided in *a* above, one key will be provided for use by an army and its corps, divisions, and attached units, or by a comparable organization. Keys will be changed at least every 3 days. In cases where the traffic load is expected to be heavy, keys will be changed more often so that the traffic load in any one key will not normally exceed 10,000 groups.

c. Separate keys and separate key-list indicators will be provided at all times for CONFIDENTIAL and RESTRICTED traffic except within a division (or smaller tactical unit) preparing its own pin and lug settings. In such units, the same pin and lug setting may be used for CONFIDENTIAL and

RESTRICTED traffic and the key-list indicators omitted; all traffic will be considered CONFIDENTIAL unless otherwise specified within the body of the message. If a message is RESTRICTED, the designation XX RESTRICTED XX will be buried in the text before encrypting. When the key-list indicator is omitted, the system indicator will be substituted in its place, and will thus appear twice in the two five-letter indicator groups.

d. Never use a previously used pin setting in combination with a different lug setting, and never use a previously used lug setting in combination with a different pin setting.

Note. If possible, in order to avoid delays when messages of different classifications must be enciphered or deciphered using different keys, one or more converters should be kept set up according to the key in which the majority of the traffic is enciphered.

18. Setting Rotor Pins

a. When the pins are placed to the right or effective position, they affect the operation of the machine; when placed to the left, they are in a noneffective position. To set the pins, proceed as indicated in *b* below.

b. Open the outer cover of the converter, and raise the inner lid. If the machine has been properly zeroized (par. 28), all of the rotor pins will project from the left-hand side of the rotors. If any project

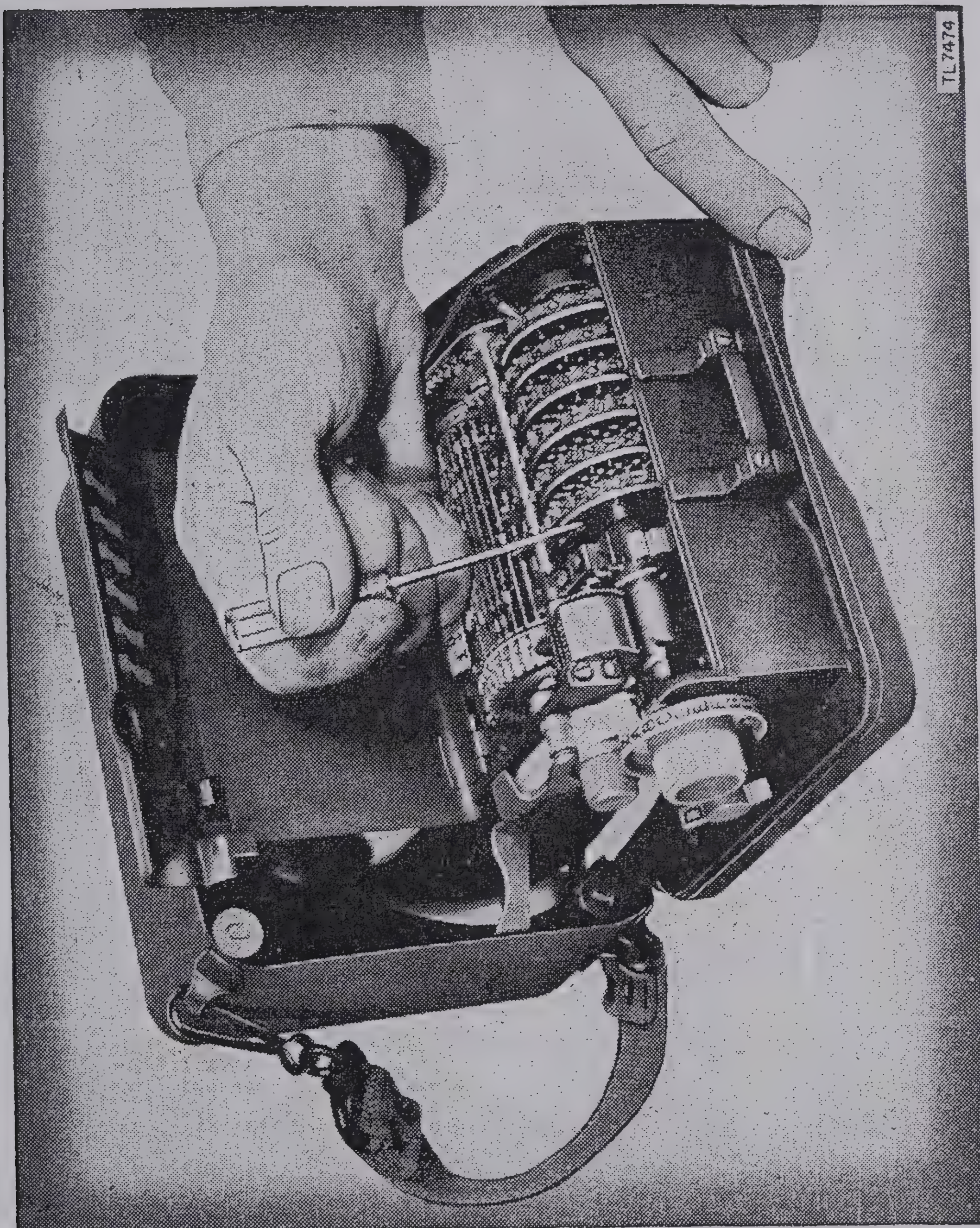


Figure 7. Setting rotor pins.

from the right-hand side, use the screw driver provided and push them to the left. This will make the setting easier. Set the pins as indicated in table I. The columns of letters and dashes represent the six rotors, from left to right. The pins, associated with the letters which are printed in the col-

Table I. Position of rotor pins (sample)

No. 1 (26)	No. 2* (25)	No. 3 (23)	No. 4 (21)	No. 5 (19)	No. 6 (17)
A	A	A	—	—	A
B	—	B	—	B	B
—	—	—	C	—	—
D	D	—	—	D	D
—	E	—	E	E	—
—	—	—	F	F	—
—	G	G	—	—	—
H	—	H	H	H	H
I	—	—	I	I	—
—	J	J	—	—	—
K	K	—	—	—	K
—	L	L	—	—	—
M	—	M	M	M	—
N	—	N	N	N	N
—	O	—	—	—	O
—	—	—	P	P	—
—	—	—	—	—	Q
—	R	R	—	—	
S	S	S	S	S	
T	—	T	T		
—	U	U	U		
V	—	—			
W	X	X			
—	—				
—	—				
—					

* Check this rotor thoroughly (see note, par. 2*c* (4), app. II). An error in setting the pins on this rotor may not appear in the 26-letter check, but will appear as an error in the message; therefore, it is important that the operator check the position of each pin on this rotor to insure that it conforms to the position shown in this pin setting.

umns are to be pushed to the right, or effective, position. Where a dash appears, the pin associated with the omitted letter will remain at the left, or noneffective, position. Thus, following the sample table, the pins under letters A and B on rotor number 1 should be moved to the right, or effective, position. The pin under letter C on rotor number 1 will remain at the left, or noneffective, position, etc. A knife blade or the special screw driver provided may be used to set the pins (fig. 7). Each pin must be moved all the way to the left or right. Garbles will result if pins are left in an intermediate position. Care in setting the pins will prevent loss of time later. The effective period for a particular setting must be known in order that the pins will be reset at the proper time. (Information regarding the preparation of a table of pin settings will be found in par. 1, app. II.)

Table II. Position of drum-bar lugs (sample)

1. 0–4	10. 0–5	19. 1–0
2. 3–0	11. 5–6	20. 1–0
3. 3–0	12. 0–6	21. 1–0
4. 3–5	13. 0–6	22. 1–0
5. 3–5	14. 0–6	23. 1–0
6. 2–5	15. 0–6	24. 1–0
7. 2–5	16. 0–6	25. 1–0
8. 0–5	17. 1–6	26. 1–0
9. 0–5	18. 1–0	27. 1–0

26-letter check

NIHTZ DXAJJ KVSIT HKNKO NAGZR I

19. Setting Drum-Bar Lugs

Lugs are effective in any position except the two marked "♀". To set the lugs, proceed as follows:

a. Open the inner lid and observe the drum in the

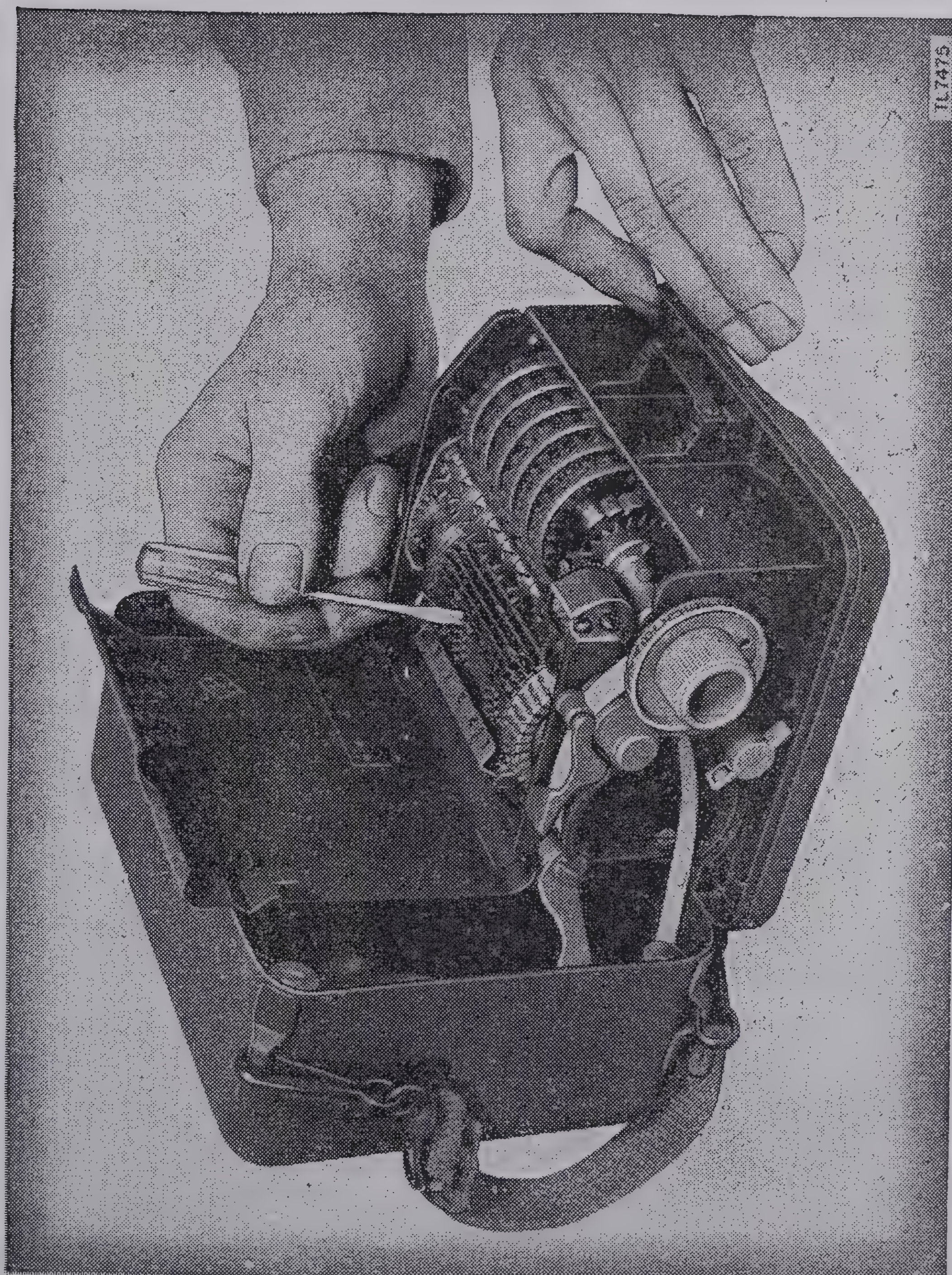


Figure 8. Setting drum-bar lugs.

rear of the machine. Each of the 27 drum bars has two movable lugs which may be placed in effective positions 1 through 6, or in two noneffective positions labeled "♀". In table II, the three columns of numbers, 1 through 9, 10 through 18, and 19 through 27, represent the 27 drum bars. The numbers opposite each drum bar number denote the positions which the two lugs on each drum bar will occupy. These positions are indicated on the machine by the number plate (29) behind the drum.

b. For example, on bar 1, the left-hand lug will be moved to the left zero position and the right-hand lug to position 4. On bars 2 and 3, the left-hand lugs will be moved to position 3 and the right-hand lugs to the right zero position. On bars 4 and 5, the left-hand lug will be moved to position 3, and the right-hand lug to position 5, etc.

c. Turn the setting knob (8) to release the drum lock and to allow the drive knob to rotate the drum. Use the special screw driver provided to move the lugs from one position to another (fig. 8). When correctly placed, each lug will lock in position in a small hole. When moving a lug, push it slightly toward the front of the machine to release it, before attempting to slide it to another location. *Be sure that the lug catches in the hole at the new position.* If a lug is allowed to remain in an intermediate position, it will jam the machine. A click can be heard when the lug is properly placed.

d. It is recommended that whenever possible the left-hand lugs on each drum bar be placed in positions 1, 2, 3, and the left zero, and the right-hand lugs be placed in positions 4, 5, 6, and the right zero. When all lugs have been properly set, turn the drive knob until the drum locks into place. (Information on the preparation of a table of lug settings may be found in par. 2, app. II.)

20. Twenty-Six-Letter Check

a. Every pin and lug setting will be accompanied by a 26-letter check. Using this check, the operator of Converter M–209–(*) will verify his preliminary settings. The operator will always make the check after setting the pins and lugs, before any messages are enciphered or deciphered.

b. Insert the paper tape according to instructions given in paragraph 31.

c. Make certain that the ink pad contains enough ink for legible printing. (If it does not, replace the pad from the ink-pad can clamped to the outer cover.) Turn the setting knob several times to ink the type wheel thoroughly.

d. With the inner lid closed, depress the reset button and turn the reset knob to zeroize the letter counter. The right-hand zero of the letter counter must be completely in view. A click will be heard when it comes into place.

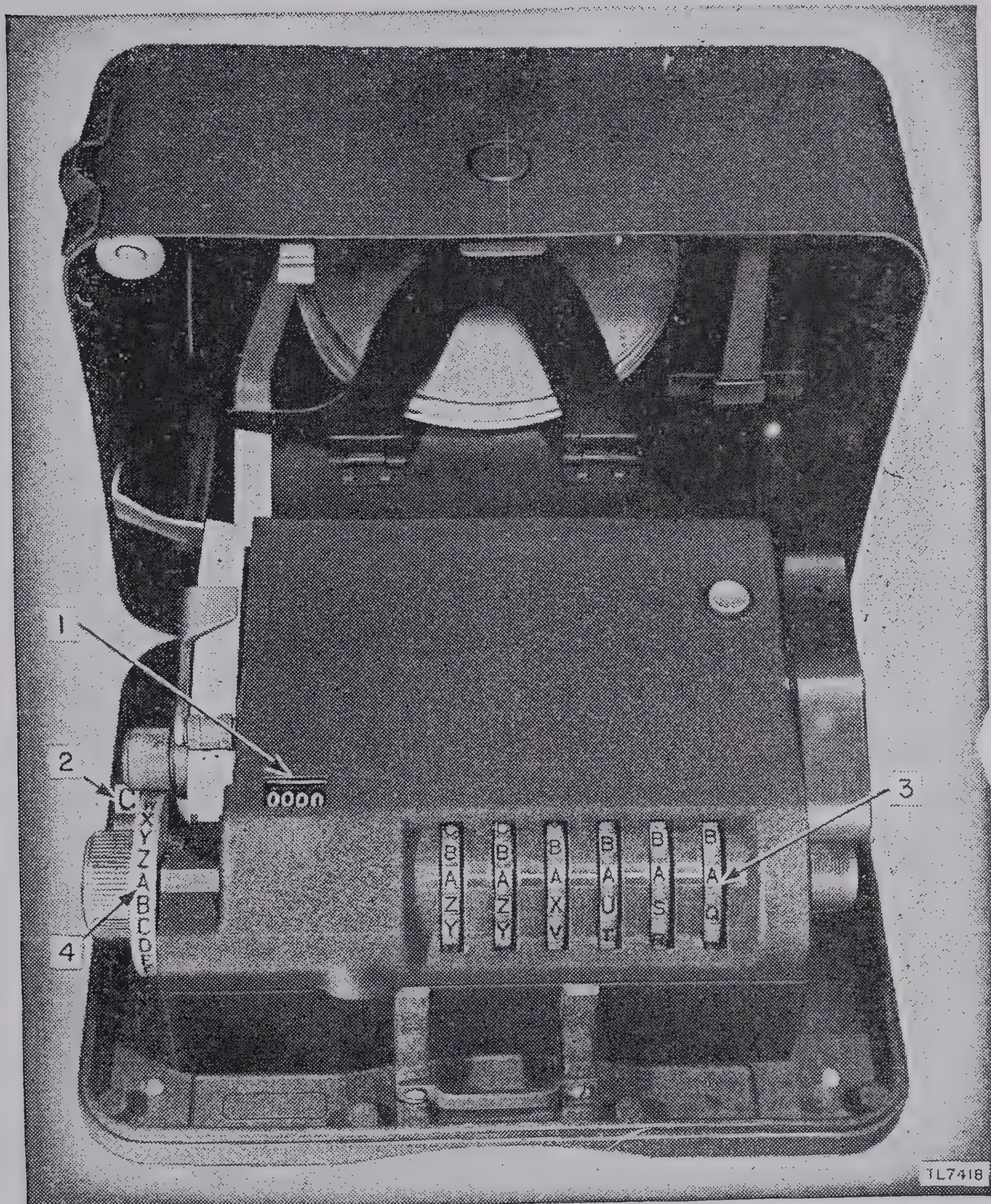
e. Set the encipher-decipher knob in the C (cipher) position.

f. Set the initial alinement of AAAAAA on the rotors by turning them individually until the letter A of each rotor lines up with the white bench mark (fig. 9).

g. Turn the indicating disk until the letter A is on line with the indicating index, and encipher it by operating the drive knob. Be sure that the drive knob is turned until it locks in place. Continue the encipherment of A's in the same manner until the letter counter shows that 26 letters have been enciphered. If the letter A is already alined on the indicating index at the end of an operating cycle, the indicating disk must be moved to another letter and returned to A in order to release the drum lock, which prevents turning the drive knob.

h. Advance the paper tape by turning the paper-feed knob until the paper can be torn off at the cutting edge.

i. Compare the tape with the 26-letter check published with the pin and lug setting. If the tape and the 26-letter check are identical, the pins and lugs have been set correctly; if they differ by one or more letters, there is an error in the initial settings of the converter which must be corrected before proceeding with any encipherment or decipherment. (After setting up the converter according to the sample pin and lug setting composed of tables I and



(1) Counter set on 0000.
(2) Encipher-decipher knob set in the C position.
(3) Key wheels aligned to AAAAAA.
(4) First letter A located on indicating disk.

Figure 9. Converter set to make 26-letter check.

II, verify the set-up by means of the 26-letter check in table II.)

Note. In certain instances the 26-letter check will not insure that all the pins on a particular rotor are correctly set. In such a case the pin and lug setting will include a note calling attention to the fact that this rotor must be given a special check (tables I and IV and note, par. 2*c*(4), app. II).

21. Errors Caused by Incorrect Settings

If the converter as set up fails to yield the correct check, the error can usually be located without rechecking the complete setup. The first step is to decide whether the mistake was made in setting the pins or in setting the lugs. In nearly every case an inspection of the operator's incorrect check will lead to a correct assumption, as explained below.

a. Pin Error. The following is an example of an error made in pin settings.

(Tables I and II were used to set the machine.)

Correct check:

NIHTZ DXAJJ KVSIT HKNKO NAGZR I

Operator's check:

LIHTZ DXAJJ KVSIS HKNKO NAGZR G

1 15 26

Note that only a few incorrect letters appear in the operator's check. (Compare with the example of a lug error in *b* below.) A pin error can be located as follows:

(1) Determine the position of the errors in the 26-letter check. In the example, the 1st, 15th, and 26th letters of the operator's check are wrong.

(2) Find the 1st, 15th, and 26th columns of the chart below and check the pins indicated by the letters in each of these columns.

Pin Locator Chart

(This chart may be extracted, unclassified)

Position of Letter in Check	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rotor No. 1	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C
Rotor No. 2	O	P	Q	R	S	T	U	V	X	Y	Z	A	B	C
Rotor No. 3	N	O	P	Q	R	S	T	U	V	X	A	B	C	D
Rotor No. 4	M	N	O	P	Q	R	S	T	U	A	B	C	D	E
Rotor No. 5	L	M	N	O	P	Q	R	S	A	B	C	D	E	F
Rotor No. 6	K	L	M	N	O	P	Q	A	B	C	D	E	F	G

Position of Letter in Check	15	16	17	18	19	20	21	22	23	24	25	26
Rotor No. 1	D	E	F	G	H	I	J	K	L	M	N	O
Rotor No. 2	D	E	F	G	H	I	J	K	L	M	N	O
Rotor No. 3	E	F	G	H	I	J	K	L	M	N	O	P
Rotor No. 4	F	G	H	I	J	K	L	M	N	O	P	Q
Rotor No. 5	G	H	I	J	K	L	M	N	O	P	Q	R
Rotor No. 6	H	I	J	K	L	M	N	O	P	Q	A	B

(*a*) According to column 1, the following pins must be checked: P on rotor No. 1, O on rotor No. 2, N on rotor No. 3, M on rotor No. 4, L on rotor No. 5, and K on rotor No. 6. In the particular example given, O on rotor No. 2 is found to be in error.

(*b*) In the same way, according to column 15, check D on rotor No. 1, D on rotor No. 2, etc. In the example given, F on rotor No. 4 is found to be in error.

(*c*) Check the pins indicated by column 26. (O on rotor No. 2 is seen to be a repeat of O on rotor No. 2 in column 1. Therefore this pin has already been corrected.)

b. Lug Error. The usual lug error is that of one lug placed in the wrong position. The following example illustrates this type of error.

Correct check:

NIHTZ DXAJJ KVSIT HKNKO NAGZR I

Operator's check:

NHGUZ DXAKJ KVRHU GKNKO NAGZS J

(1) Note the following characteristics:

(*a*) Several errors appear.

(*b*) The incorrect letter H is directly before the correct letter I in the alphabet; the incorrect letter G is directly before H in the alphabet; U is directly after T in the alphabet, etc. (A pin error seldom exhibits this characteristic.)

(2) To correct, check the complete lug setup by comparing it with the table of lug settings. (The results of the above example will be produced if on either No. 4 drum bar or No. 5 drum bar the position of the lugs is 3–6 instead of 3–5.)

Section IV. OPERATION OF EQUIPMENT

22. Operation Cautions

a. GENERAL. Most failures of Converter M–209–(*) can be attributed to careless or faulty operation rather than to the machine. The converter is designed to withstand hard usage in the field, and is therefore rugged in its construction, but it must be handled with a reasonable amount of care if it is to give satisfactory service.

b. CHECK LIST. Certain cautions mentioned throughout this part of the manual, if properly observed, will help to keep the machine running smoothly. These cautions appear below as a check list for the new operator:

(1) In making preliminary settings, each rotor pin must be pushed all the way to the right or left; do not leave a pin in an intermediate position.

(2) Drum-bar lugs must be properly seated in the holes provided for them.

(3) The reset knob must click into place after being turned, and a complete figure must be visible on the letter counter.

(4) Rotors will click when moved into position. Do not allow a rotor to remain in an intermediate position.

(5) Turn the drive knob in a complete cycle until it locks. Avoid an excessively rapid or jerky motion.

(6) The indicating disk must not be moved until the drive knob has made a complete cycle.

(7) *Never use force to clear a jammed machine.* Paragraph 69 gives instructions for eliminating a jam.

(8) Check the supply of paper tape in the paper-feed mechanism (par. 31).

(9) Check the ink pad for adequate inking (par. 32).

23. Types of Indicators

a. Every message enciphered by Converter M–209–(*) will carry the following two indicators; they will appear in two five-letter groups immediately preceding and following the cipher text:

(1) The *system indicator,* which identifies the message as having been enciphered by means of Converter M–209–(*), and which is used in deriving the message rotor alinement.

(2) The *message indicator,* from which is derived the actual rotor alinement used to encipher the message. (This alinement is called the message rotor alinement. It is derived as explained in par. 24, and is *never* transmitted.)

b. In addition, some messages will carry a *key-list indicator,* which will indicate the specific pin and lug setting in use. The *key-list* indicator will consist of a digraph assigned to the pin and lug

setting according to the following rules, and, when transmitted, will appear in the indicator groups preceding and following the cipher text.

(1) Each digraph will consist of two different letters.

(2) Digraphs beginning with I, J, K, L, M, and N are reserved for joint, combined, and certain special systems, and will not be used except with those systems. The digraph EM will be used only for emergency keys.

(3) *Each* pin and lug setting will be assigned a *random* digraph, subject to the provisions of (1) and (2) above. A headquarters will *not* use the same digraph continuously.

c. In tactical operations (simulated or actual) only, use of the key list indicator must be specifically authorized by the headquarters issuing the pin and lug settings. For security reasons, in the operation of the Converter M–209–(*), the key list indicator is *not* used unless the combination of call signs and date-time group on the message is insufficient to identify the key list employed in the encipherment of the message. When the key-list indicator is not used, the system indicator will be substituted in its place, and will then appear twice in the two five-letter indicator groups.

d. The above indicators will be arranged on the cipher message as explained in paragraph 25.

24. Deriving Message Rotor Alinement

Whenever Converter M–209–(*) is used to encipher a message, the actual alinement of the rotors will be determined as explained below.

a. MESSAGE INDICATOR. After the preliminary settings have been made and checked, the first step in preparing to encipher a message is to select the message indicator. This indicator is a group of six letters selected at random by the operator, and *will be different for every message or message part enciphered*. The six-letter message indicator selected should be recorded temporarily, since it will later be included in the indicator groups at the beginning and end of the message. The following procedure is recommended for the selection of random message indicators:

(1) Set the encipher-decipher knob at C and the letter counter at 0000.

(2) Rotate each rotor individually a *random* number of letter positions, starting with the first rotor. (Turning each rotor always an equal number of spaces is *not* random.)

(3) Upon completion of this random selection, the letters alined along the bench mark form the message indicator.

(4) *Never* use an alinement found on the machine, or one which results when the letter counter is returned to 0000; *never* use an actual or phonetic

word (unless it occurs by pure chance), and never use any systematically selected indicator. *It is essential that the message indicator be selected in a completely random manner.*

b. Message Rotor Alinement.† (1) Assume, for example, that the six letters of the randomly selected message indicator are D K S L G J. Select any letter of the alphabet by spinning the indicating disk at random. Record this letter temporarily, since it will be included in the indicator groups. Assume that spinning the disk yields the letter W. With the rotors alined at the letters of the message indicator, encipher the selected letter (in this case, W) 12 consecutive times, the cipher resultants of which will be printed on the tape. Tear the tape from the machine. The message rotor alinement is selected from the 12 cipher-text letters appearing on the tape, as explained below.

(2) Assume that the 12 cipher-text letters printed on the tape are

P D E Z U   U M L U Y   O B

Reset the letter counter to 0000. On the first rotor (at the left, facing the machine) find the first cipher-text letter resulting from the repeated encipherment of the single selected letter, and set it at the bench mark. In following the example, set P on the first rotor at the bench mark. Find the second

† The explanation should be followed step by step with a converter set up according to the sample pin and lug setting shown in table IV, page 141.

cipher-text letter D, on the second rotor and set it at the bench mark. Set E on the third rotor at the bench mark. Continue this process until the six rotors have been alined. If the cipher-text letter sought on a rotor does not appear among the letters on the rotor, that letter on the tape is canceled or passed, and the next letter on the tape which does appear on the rotor is alined at the bench mark. In the example, Z does not appear on the fourth rotor. Pass it by and set U, which does appear on the fourth rotor, at the bench mark. Since the next U does not appear on the fifth rotor, pass it by and set M at the bench mark. Set the sixth rotor to L. Disregard the remaining unused letters, U, Y, O, B. It is thus seen that the sequence of letters on the tape, P D E ~~Z~~ U ~~U~~ M L ~~U~~ ~~Y~~ ~~O~~ ~~B~~ yields the actual rotor setting P D E U M L, which is alined along the bench mark. The setting so determined is called the *message rotor alinement* and is the alinement of the rotors when encipherment of the message text is begun. Destroy the tape on which the 12 letters are printed.

Note. In rare cases, 12 encipherments of a randomly selected letter will yield *less* than 6 usable letters. If this situation arises, select a new message indicator, and re-encipher the randomly selected letter.

25. Recording Indicators

Assume that the six letters selected at random for

the message indicator are D K S L G J, the letter consecutively enciphered 12 times is W, and the key list indicator of the effective pin and lug setting is VC. The two indicator groups will appear as follows (note that their order is the same at both the beginning and end of the message):

WW	DKS LGJ	VC	. . . .	WW	DKS LGJ	VC
1	2	3		1	2	3

(cipher text)

1 The first and second letters of the two groups form the *system indicator* (One letter repeated in these positions serves to indicate that Converter M–209–(*) was used to encipher the message.)

2 The third through the eighth letters form the *message indicator.*

3 The ninth and tenth letters form the *key-list indicator,* which designates the specific pin and lug setting used. When the key-list indicator is omitted (see par. 23*c*), the system indicator will be inserted in its place as follows:

WW	DKS LGJ	WW	. . . .	WW	DKS LGJ	WW
1	2	3		1	2	3

(cipher text)

Caution: UNDER NO CIRCUMSTANCES WILL THE MESSAGE ROTOR ALINEMENT (the actual alinement of the rotors used for the encipherment of the message) EVER BE TRANSMITTED.

26. Encipherment

a. PRELIMINARY INSTRUCTIONS. The following steps for enciphering a message with Converter M–209–(*) are presented in a numbered sequence designed to help the operator learn the process by performing the operations:

(1) Make certain that the drive knob is in the locked position. If it is not locked, turn it until it clicks and will turn no more. The knob cannot be turned again until the indicating disk has been moved. Leave the drive knob in the locked position until all adjustments have been made.

(2) Turn the encipher-decipher knob so that the letter C is up and facing the front.

(3) Zeroize the letter counter. This will insure that the enciphered text will be printed in groups of five letters, and will show the exact number of letters enciphered.

(4) Set up a random alinement of the rotors—for example, D K S L G J (par. 24*b*(1)). The letters of this alinement form the *message indicator*. The flat end of the tweezers may be used for turning the rotors individually. *Do not use an eraser tip.* Each rotor, upon coming into place, will click audibly; do not leave a rotor in an intermediate position. Make a note of the message indicator so that it may be referred to later.

(5) Select any letter of the alphabet, for exam-

ple, the letter W, by spinning the indicating disk at random. Make a note of this letter; it is later doubled to form the *system indicator*.

(6) Encipher the selected letter 12 times. (Assume that the encipherment yields P D E Z U U M L U Y O B.) Tear off the tape.

(7) Reset the letter counter to 0000.

(8) Aline the rotors, from left to right, to the first six usable letters of the 12 obtained in step (6)—in this case P D E U M L. This setting is called the *message rotor alinement*.

(9) Advance the tape about 6 inches to allow for insertion of the message heading and indicator groups by hand. (If the supply of paper tape is exhausted, each cipher-text letter may be copied from the reproducing disk immediately after the rotation of the drive knob. The first letter, nearest the front of the converter, is used.)

b. PROCEDURE. Encipher the following example message: NEED REINFORCEMENTS IMMEDIATELY AMMUNITION WILL NOT LAST OVER TWO HOURS.

(1) Turn the indicating disk until the first letter to be enciphered, N, lines up with the indicating index, and release the setting knob.

(2) Turn the drive knob until it locks. Avoid a rapid or jerky movement of the drive knob. A moderate, steady motion is preferable. Complete the op-

erating cycle before enciphering another letter, or jamming of the mechanism will result.

(3) Locate the second letter of the message, E, on the indicating disk and rotate the drive knob again. This procedure is repeated for all letters of the clear text.

(4) Converter M–209–(*) was originally designed to encipher one Z between each word so that the deciphered text would appear on the tape in word lengths. As a security measure, the following variations of this spacing will be used for *every* message. Between some words, omit the Z; between other words, encipher two Z's; between remaining words, space normally (one Z). The following example illustrates the use of prescribed variations of spacing. Note that some words have no space between them.

```
                        (Z)
NEEDREINFORCEMENTS IMMEDIATELY
(ZZ)            (ZZ)        (Z)
   AMMUNITION    WILLNOT LAST
          (ZZ)
OVERTWO   HOURS
```

Caution: NEVER USE MORE THAN TWO Z'S BETWEEN WORDS. NEVER USE A DISPROPORTIONATE NUMBER OF ANY ONE OF THE VARIATIONS. NEVER CHOOSE CHARACTERISTIC POINTS FOR PLACING ANY ONE OF THE VARIATIONS. (For example, do

not consistently place double Z's before and after an internal address or signature.)

(5) If the counter reading is not divisible by five after the last letter of the message or message part has been enciphered, encipher Z and then, if necessary, encipher enough different nulls (random letters selected by spinning the indicator disk at random, but with no repetitions) to advance the letter counter to a reading divisible by five.

(6) When the message has been completely enciphered, advance the paper tape 2 or 3 inches and tear it off at the cutting edge.

(7) Since the drive knob is locked at the end of each operating cycle, the indicating disk must always be moved before another letter can be enciphered or deciphered. Occasionally the desired letter is already in position before the indicating disk is moved. If this happens, move the disk to another letter and return it to the desired letter. This will release the lock and allow the drive knob to be turned.

(8) Write at the beginning of the tape all necessary transmitting data, followed by the system indicator, WW in this example, message indicator, D K S L G J in this example, and key-list indicator (assume that the key-list indicator of the pin and lug setting is VC). The indicators form two five-letter groups. Repeat the indicators in the same order at the end of the message. The message ele-

ments will appear on the tape as follows: (Message heading) WWDKS LGJVC . . . (cipher text) . . . WWDKS LGJVC (Message ending).

c. DIVIDING LONG MESSAGES INTO PARTS. Messages exceeding 100 groups in length must be divided into two or more approximately equal parts before encipherment so that no part exceeds 100 groups. A new message indicator and system indicator will be selected for each part. The two indicator groups will appear at the beginning and end of each message part.

27. Decipherment

The deciphering operator must have actual settings on his machine which are identical with those used by the enciphering operator. Retaining the settings of tables I and II, decipher the message which was enciphered in paragraph 26*b*. Proceed as follows:

a. Make certain that the drive knob is in the locked position.

b. Turn the encipher-decipher knob to the C position. (If the encipher-decipher knob is left at the D position, errors will sometimes result.)

c. Zeroize the letter counter.

d. Check the indicator groups at the beginning of the message with those at the end to make sure they are the same, and aline the rotors in accordance with the message indicator, D K S L G J.

e. Encipher 12 times the repeated letter W, given as the system indicator for the message. Tear off the tape.

f. Reset the letter counter to 0000.

g. Aline the rotors to the *message rotor alinement* (P D E U M L, the first six usable letters of the 12 obtained in subparagraph *e* above).

h. Turn the encipher-decipher knob to the D (decipher) position.

i. Proceed as in encipherment; locate the cipher letters one by one on the indicating disk, and operate the drive knob in one complete cycle each time. Disregard the spaces between the groups of the cipher text. Carry in mind one five-letter group at a time so that it will not be necessary to look at the text for each letter; this will keep errors at a minimum.

j. Upon completion of decipherment, advance the tape until the printed clear text is beyond the cutting edge, and tear it off. Since one or two Z's or no spaces were used between words when the message was enciphered, the clear text will appear with one or two spaces between some words and with no spaces between other words. Before delivery to the addressee, every message must be restored to normal spacing. Delete any nulls which may have been added at the end of the message. The indicators are not to be included in the clear-text copy of the message delivered to the addressee.

28. Zeroizing the Machine

When the converter is to be closed at the end of a day or a period of operation, the pins and lugs must be zeroized. First, push all the rotor pins to the left, or noneffective, position. Second, move all lugs to the zero positions on the drum bars. Tear off any tape which contains printing, and close the outer cover of the machine. The converter should then be placed in the canvas case provided, and kept in a dry place until used again.

29. Spacing

a. AUTOMATIC SPACER. Five-letter cipher groups are obtained only when the encipher-decipher knob is set in the encipher position. This spacing is automatic and is ignored by both enciphering and deciphering operators.

b. Z-SPACING. When the operator enciphers one or two Z's between words of clear text, these Z's will appear in the deciphered message as one or two spaces, respectively. When the operator does not encipher Z between words, no space will appear (par. 26*b*(4)). Spaces in the deciphered text are caused by the automatic suppression of the printing of the letter Z when the encipher-decipher knob is in the D position. Such a word as ORGANIZED will appear in clear text as ORGANI ED, but the missing letter can easily be supplied from the context of

the message. The printing of the Z is prevented *only* when the encipher-decipher knob is set for deciphering.

30. Use of Letter Counter

An operator who wishes to check a word or correct an error, or who has lost his place in the message he is enciphering or deciphering, need not start at the beginning of the message if he has a proper understanding of the letter counter. Whenever it is necessary to check back in the message for any reason, proceed as follows:

a. Determine the place in the message where the error occurs. Count the letters from the beginning of the message to the error. If the count is made from clear text, remember to count spaces also. In cipher text, the number of groups can be multiplied by five (there are five letters in each group), and any extra letters which are correct can be added to the product. For example, in the message used in paragraph 26*b*, "NEED REINFORCEMENTS IMMEDIATELY . . .", a mistake might have been caused by skipping a letter in decipherment so that the following text resulted: NEEDREINFORCEMENTS QCTLV, etc. A count of the letter in error will show that all letters (including spaces) through the 19th are correct.

b. Turn the letter counter back until it reads 19.

Count the cipher-text letters up through the 19th (three groups plus four letters), and begin from there by deciphering the 20th letter. This process may be used for re-enciphering or redeciphering any portion of a message or message part. (Note security precaution, par. 34*a*(4).)

31. Inserting Paper Tape

To insert fresh tape into the paper-feed mechanism, release the hinged guard which holds the roll of paper in place and allow the guard to tilt forward against the inner lid. Remove the empty spool and place a new roll of tape over the pin. (The tape must unroll in a counterclockwise direction.) Pass the end of the tape through the slot in the hinged guard, bring the tape forward, and insert it in the tape slot just above the encipher-decipher knob. Push the tape through the tape channel until it appears between the type wheel and the tape-advancing rollers. The tape must pass under the paper-guide spring immediately behind the type wheel. Next pass the tape between the tape-advancing rollers (fig. 16), while depressing the paper-pressure arm.

32. Inserting Ink Pads

Additional ink pads will be found in one of the small metal containers held by spring clamps in the outer cover of the machine. When an ink pad becomes so

dry that printing on the tape is not clear, the pad should be disposed of, and a new one should be inserted. To replace a pad, open the inner lid of the converter, use the tweezers to remove the old pad, and insert a new one. The life of the pad, before replacement is necessary, can be prolonged by turning it end for end.

33. Equipment Performance Check List

a. GENERAL. The equipment performance check list covers the mechanical settings and adjustments necessary for operation of Converter M–209–(*). Preparatory steps, the operational steps of enciphering and deciphering, and zeroizing are given item numbers in the check list. The "Item" column lists the points where operations or adjustments are necessary. The "Action" column indicates what operation or adjustment is to be performed. The "Normal indication" column describes the result of the operation or adjustment if the converter is operating satisfactorily. The "Corrective measure" column lists suggestions for corrective actions to be taken in case the converter does not function normally.

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b. PERFORMANCE CHECK LIST FOR CONVERTER M–209–(*).

PREPARATORY

Item No.	Item	Action	Normal indication	Corrective measure
1	Rotor pins.	Set according to current key.	Effective pins project to the right from rotors; noneffective to the left.	Push pins all the way to the left or right. Do not leave in an intermediate position.
2	Drum-bar lugs.	Set according to current key.	Effective lugs line up under proper numbers on number plate (29); noneffective under ♀	Move lugs till they catch in the small hole under the proper numbers. A click will be heard when each lug is correctly placed. Do not leave any lug in an intermediate position.
3	Inner lid....	Close lid...........	Audible click.........	Press down firmly.
4	Drive knob.	Lock drive knob....	Audible click; knob will not turn in either direction.	Turn clockwise until click is heard.

5	Encipher-decipher knob.	Set knob in encipher position.	Letter C on knob is visible from front of converter. Knob clicks as it is moved into position.	Set in correct position.
6	Letter counter.	Zeroize	Four zeros show through letter-counter window. Reset knob clicks.	Press reset button and turn reset knob till four zeros line up in letter-counter window; release reset button; turn reset knob till a click is heard. Check to be sure all four figures are still zeros.

b. Performance Check List for Converter M–209–(*) (contd.)

ENCIPHERING

Item No.	Item	Action	Normal indication	Corrective measure
7	Message indicator.	Select (par. 24*a*).	Random alinement of rotors.	Rotate rotors individually random number of spaces.
8	System indicator.	Select (pars. 24 and 25).	Random letter on indicating disk lined up with indicating index.	Spin indicating disk till letter lines up.
9	Indicating disk and drive knob.	Aline selected letter with indicating index. Turn drive knob. Repeat till same letter has been enciphered 12 times.	Tape advances; printed letters appear on tape; letter counter registers with each letter; click is heard at end of cycle.	Turn drive knob till it locks. Check to see if tape is properly inserted. If letters do not print, check ink pad and type wheel (pars. 47 and 46).
10	Lettercounter	Zeroize	Same as Item 6	Same as Item 6.

11	Rotors......	Aline according to first six usable letters of the 12 obtained in item 9.	Rotors lined up with six letters of message rotor alinement on bench mark.	Turn rotors to proper position with finger or tweezers.
12	Paper tape..	Advance tape to allow for insertion of message heading and indicator groups.	About 6 in. of clean tape is visible above type wheel.	Advance tape by turning paper-feed knob.
13	Message....	Encipher by repeating Item 9 for each letter of the message.	Same as Item 9......	Same as Item 9.
14	Paper tape..	Advance tape till printing is 2 or 3 in. beyond cutting edge of paper-pressure arm; tear off.		

b. Performance Check List for Converter M–209–(*) (contd.)

DECIPHERING

Item No.	Item	Action	Normal indication	Corrective measure
15	Encipher-decipher knob.	Set knob in encipher position.	Same as Item 5......	Same as Item 5.
16	Lettercounter	Zeroize............	Same as Item 6......	Same as Item 6.
17	Rotors.....	Aline according to message indicator.	Rotors lined up with six letters of indicator on bench mark.	Same as Item 11.
18	Indicating disk and drive knob.	Aline system-indicator letter with indicating index. Turn drive knob. Repeat till same letter has been enciphered 12 times.	Same as Item 9......	Same as Item 9.

19	Letter counter.	Zeroize............	Same as Item 6......	Same as Item 6.
20	Rotors.....	Aline according to first six usable letters of the 12 obtained in Item 18.	Same as Item 11.....	Same as Item 11.
21	Encipher-decipher knob.	Set knob in decipher position.	Letter D on knob is visible from front of converter. Knob clicks as it is moved into position.	Set in correct position.
22	Rotor pins..	Push all pins to non-effective position.	All pins extend from left side of each rotor.	Push pins to left with screw driver.

b. Performance Check List for Converter M–209–(*) (contd.)

	Item No.	Item	Action	Normal indication	Corrective measure
ZEROIZING	23	Message....	Decipher by repeating Item 9 for each letter of the message.	Same as Item 9......	Same as Item 9.
	24	Drum-bar lugs.	Set all lugs in noneffective position.	Lugs line up in small holes under ♀ marks on number plate.	Move lugs till they are all in noneffective position.
	25	Paper tape..	Tear off any printed tape and destroy.		

34. Security Precautions for the Operator

To maintain the security which Converter M–209–(*) provides, the converter must be used in strict accordance with *all* prescribed procedure. The following rules must be carefully observed:

a. Select at random a new *message indicator* and system indicator for each message or message part enciphered.

(1) Never use an alinement found on the converter.

(2) Never use an alinement which results from returning the letter counter to zero.

(3) *Never use a message indicator which has been used on any other message.*

(4) *When a message must be re-enciphered for a service or for any other reason, never use the same message indicator or message rotor alinement that was used for the first encipherment.* When a message has once been transmitted, it will never be re-enciphered unless the entire message is paraphrased according to instructions contained in AR 380–5; a new message indicator and system indicator must be selected.

b. Be very careful to avoid errors while deriving the message rotor alinement.

c. Never transmit the *message rotor alinement.*

d. Vary the space between words by omitting Z

between some words and enciphering one or two Z's between others.

e. Destroy all printed tape not pasted to a message blank.

f. To fill an incomplete final group, encipher a Z followed, if necessary, by different enciphered nulls.

g. If a message has stereotyped phraseology at the beginning or end, use authorized means of avoiding stereotypes.

h. Messages exceeding 100 groups in length must be divided into two or more approximately equal parts so that no part exceeds 100 groups.

i. Converter M–209–(*) will never be used for SECRET traffic except when a system normally authorized for SECRET traffic is not available. When a SECRET message must be enciphered by means of Converter M–209–(*), the CONFIDENTIAL key will be used and the word SECRET, set off by two X's on each side, will be buried in the text before encrypting.

j. Converter M–209–(*) will not be used for CONFIDENTIAL traffic above the level of corps or comparable organization except as authorized by the Army Security Agency of the theater or the War Department.

k. Separate keys and separate key-list indicators will be provided at all times for CONFIDENTIAL and RESTRICTED traffic except within a division (or smaller tactical unit) preparing its own pin and

lug settings. In such units, the same pin and lug setting may be used for CONFIDENTIAL and RESTRICTED traffic and the key-list indicators omitted; all traffic will be considered CONFIDENTIAL unless otherwise specified within the body of the message. If a message is RESTRICTED, the designation XX RESTRICTED XX will be buried in the text before encrypting. When the key-list indicator is omitted, the system indicator will be substituted in its place, and will thus appear twice in the two five-letter indicator groups.

Section V. CAUSES AND CORRECTION OF GARBLES

35. General

Every code clerk should be acquainted with errors likely to occur in enciphering and handling messages, as an insurance against their occurrence in outgoing traffic; and every deciphering clerk should be able to test for these errors and correct them. In Converter M–209 messages, many of the more likely errors are easy to correct. Therefore, a reasonable amount of time spent in trying to decipher messages, which contain such errors, will prevent many services and result in increased communications efficiency and cryptosecurity. In the following paragraphs, the procedure to be applied in deciphering a

garbled message appears in italics to distinguish it from explanatory and supplementary instructions. Before trying any of the steps given below, the deciphering operator should check his own work to see that he has not deviated from prescribed operating procedure or made careless errors. It is suggested that the procedures given in paragraphs 36 and 37 be copied in abbreviated form and kept with the converter for convenient reference. Such extracts must retain the RESTRICTED classification.

36. Unreadable Messages

Steps listed in *a* through *g* below should *always* be applied before servicing. Steps listed in *h* through *u* below should be applied as time permits or as they seem to be applicable. One of the following procedures will yield plain text in almost every case.

a. Check the group count. If one or more groups are missing, advance the rotors one step for each missing letter and decipher beginning with the first group. If one or more groups are added or repeated, delete the proper number of groups from the beginning of the cipher text and decipher. The first group or groups may have been lost in handling or one or more groups may have been repeated or added at the beginning.

b. Check the second appearance of the message indicator, and if different from the first, try it.

c. Decipher several groups and examine the result for fragments of plain-text words. The appearance of parts of plain-text words on the tape is an indication that one rotor (or sometimes two) was not alined to the appropriate letter of the message rotor alinement. It does not necessarily follow, however, that even partial plain text will always be produced when there is an incorrect alinement of one rotor; the text thus produced might possibly be completely garbled.

(1) *If partial plain text is found,* the only steps in the following procedure which apply are those listed in *j* through *m* below; these should be applied before servicing.

Note. If the operator will apply the steps given in paragraph 1, app. IV, before trying steps *j* through *m* below, he may find it easier to locate the exact rotor which was incorrectly alined. The steps listed in *j* through *m* below can be followed immediately after discovery of fragments of plain text. However, whenever it is possible to locate the rotor in error by means of the steps in paragraph 1, app. IV, time will be saved by so doing.

(2) *If partial plain text is not found,* proceed according to instructions in subparagraphs below. Do not skip steps in *j* through *m* below.

d. If Z occurs as the first or second letter of the 12-letter result,† omit that letter in deriving the message rotor alinement. The enciphering clerk

† The "12-letter result" consists of the 12 letters from which the message rotor alinement is derived.

would probably omit Z if he derived the 12-letter result with the encipher-decipher knob at D (decipher), since Z would appear on the tape as a space.

e. Set up the MESSAGE indicator and decipher several groups.

(1) *Examine the tape to see if plain text appears at once.* The enciphering operator may have obtained the 12-letter result, torn off the tape, returned the counter to 0000, and then enciphered the message, a procedure which would cause the message indicator to be used as the message rotor alinement.

(2) *If plain text does not appear at once, note whether the first 12 letters of the decipherment consist of the system indicator letter repeated 12 times. If so, continue to decipher.* The enciphering operator may have obtained the 12-letter result and, without tearing it off or alining the rotors to the message rotor alinement, continued with encipherment of the message.

f. With the counter at 0000, aline the rotors to the message indicator, advance the counter to 0015, and decipher beginning with the first group. If the enciphering operator left the counter at 0012 after obtaining the 12-letter result, tore off the tape, and continued with encipherment of the message without realining the rotors, the message would begin with a three-letter group which might be lost in handling.

g. Try the pin and lug setting for the previous day if the message was enciphered just after the time for

changing keys. Try the pin and lug setting for the following day if the message was enciphered just before the time for changing keys.

h. With the counter set at 0000, aline the rotors to the message rotor alinement. Turn the counter back 12 steps (that is, to the counter reading 9988) and decipher several groups. If the operator enciphered the message indicator (giving a counter reading of 0012), alined the rotors to the message rotor alinement, and then returned the counter to 0000, the encipherment of the message would begin with the rotors 12 steps out of line.

i. With the counter set at 0000, aline the rotors to the message rotor alinement, advance the counter three steps, and decipher several groups. If the operator obtained the 12-letter result, left the counter at 0012, and alined the rotors to the message rotor alinement, the message would begin with a three-letter group which might be lost in handling.

j. Form five new versions of the message rotor alinement by reversing adjacent letters two at a time, and attempt to decipher the message using each version. For example, if the message rotor alinement is LGKIBN, try GLKIBN, LKGIBN, etc. *Also check the 12-letter result for a letter which will not go on the rotor for which intended, but which will go on the one before it; if there is such a letter, derive another message rotor alinement by reversing the necessary letters,* as illustrated below:

12-letter result	*Message rotor alinement*	*New version*
LGWKI UBNCR JA	LGKIBN	LGKUIB

k. Form five new message rotor alinements from the 12-letter result by omitting, in turn, the letter belonging on rotor No. 2, that belonging on rotor No. 3, etc. For example, if the 12-letter result is MTCUZ JHGUX SK, which yields MTCUJH as the correct message rotor alinement, new versions would be MCUJHG, MTUJHG, etc. This procedure tests for the possibility that the operator has accidentally omitted a letter of the 12-letter result, or that some other error has produced the same effect.

l. Make new versions of the message rotor alinement by substituting, in turn, an appropriate letter for each letter which is likely to have been printed indistinctly on the tape by the enciphering machine or is likely to have been mistaken for another by the enciphering operator. Try each new message rotor alinement thus formed. Letters commonly substituted for other letters are shown below. (It is necessary to refer to the 12-letter result only to see if T might have been mistaken for I and therefore *not* eliminated, or if B in the sixth position of the message rotor alinement might have been mistaken for R or S and therefore erroneously eliminated.)

If the message rotor alinement contains –BBEGLOQQT

Set up instead –RSFCICOGI

For example:

12-letter result	Message rotor alinement	New version
....	JELNAB	JEINAB
....	JELNAB	JFLNAB
JWELV NTABG CL	....	JELNIA
JWELV NTABG CL	JELNAB	JELNAG

m. Make new versions of the message rotor alinement by substituting, in turn, for each letter the letter immediately before it in the normal alphabet, then the letter immediately after it. For example, if the message rotor alinement is BTLCSN, new versions are ATLCSN, CTLCSN, BSLCSN, BULCSN, etc. (If the substituted letter is not on the rotor concerned, use the letter on the rotor which precedes or follows the original letter.) The enciphering operator may have accidentally missed the system-indicator letter once in obtaining the 12-letter result and enciphered in its stead the letter before or after it. Thus if the system indicator letter is K, the operator may have enciphered KKKKLKKKKKKK, in which case the fifth letter of the 12-letter result would be the letter immediately preceding the correct letter in the normal alphabet. (If the error causes a letter of the 12-letter result to be eliminated

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when it should not be, the procedure in *k* above will yield plain text.) The procedure in this subparagraph will also apply when the enciphering operator has derived the correct message rotor alinement but has accidentally alined one of the rotors one step away from the correct letter. Furthermore, this procedure will give the message rotor alinement used by the enciphering operator if one lug on the drum of his converter was misplaced, provided the misplaced lug caused only one incorrect letter in the message rotor alinement. However, when the message is deciphered using the corrected message rotor alinement, the text will still show garbles caused by the lug error. The following examples show some types of deciphered text which may result.

Type 1:

```
     S ZT    ME    Z    Z
NOW IT AUHE TINFFORA ALLAGOODMEN
```

Type 2:

```
NOWYIS YTHE  SIMDENR KL  GNODMDN
   Z   Z     T  EFO AL    O   E
```

Type 3:

```
N        H    M       LL      EN
OOW IRY TIE THNEFNR  AMMYGOODMFO
     SZ      I   O      Z
```

Note that in the example of a "Type 1" lug error, the incorrect letters always immediately follow the

correct letters in the normal alphabet. In the example of a "Type 2" lug error, the incorrect letters immediately precede the correct letters in the alphabet. In the example of a "Type 3" error some of the incorrect letters immediately precede the correct letters in the alphabet and others immediately follow. Complete plain text may be obtained by determining the type and then substituting the correct letters as illustrated. A more detailed explanation is given in paragraph 3, app. IV.

n. If the message has been transmitted by radio, examine the message indicator for letters commonly received through error. If any, form new versions of the message indicator as illustrated below, derive new message rotor alinements, and attempt to decipher the message from each. Some of the more likely transmission errors are listed below. If the message indicator is received as DZJUCN, new versions are BZJUCN, DZJVCN, DZJUYN, and DZJUCD.

Received:	ABCDEFGHIKL MMNOOO QS STUVY
Original:	UDYBI LFS SXF GWDG JMYHIA VUQ

A table of common errors in International Morse characters may be consulted for other possible transmission errors.

o. If the message has been transmitted by teletype, form new versions of the message indicator based on

probable teletype errors. Some of the more likely teletype errors are listed below.

Received—B D E I K L S V

Original— V K I E D S L B

p. If the message was not enciphered just after or just before the time for changing keys, attempt to decipher it using the pin and lug setting for the previous day, then for the day following. The wrong pin and lug setting may have been used even though the encipherment was not performed soon after or before the time for changing keys.

q. If the originating code room uses two different Converter M–209 systems, try the pin and lug setting of the other system for the corresponding date, if this system is available. The operator may have used the wrong machine for the encipherment.

r. Check the message indicator for the letters C, E, F, O, U, and V, and any other letter likely to have been misread for another because of illegible copying by the enciphering operator. If any, form new versions of the message indicator and try each. Following are the substitutions likely to be made. Underlined letters are also listed in *n* above.

Received—C E F O O <u>U</u> <u>V</u>

Original— G F E D Q <u>V</u> <u>U</u>

s. Form five new versions of the message indicator by reversing the order of adjacent letters, and try

each one that is usable. For example, if the message indicator is received as BPHUGH, new versions would be PBHUGH, BHPUGH . . . BPHGUH (unusable), BPHUHG. This procedure will yield plain text if two adjacent letters of the message indicator have been transposed in copying or in handling.

t. Set up the message rotor alinement with the counter at 0000. Then turn the counter to 0005 and attempt to decipher beginning with the first group. If plain text does not result, turn the counter to 0010 and decipher beginning with the first group. Continue this procedure with the counter set at 0015, at 0020, etc., through 0050. If plain text results from a decipherment starting with the counter reading at 0005, one cipher group is missing, if plain text results from a decipherment starting with the counter reading at 0010, two cipher groups are missing, etc.

u. Set up the message rotor alinement, turn the counter back two steps, and decipher beginning with the first group. This checks for the possibility that the operator has alined the rotors to the message rotor alinement with the counter at 0012, then turned the counter to 0010 in order to start with a five-letter group.

37. Messages which Yield Some Plain Text, then Garbles

When a message yields plain text from the beginning

but bécomes unreadable at some point within the message, one of the following procedures will almost always correct the garbles.

a. Note whether either a 4-letter or a 6-letter group appears at the point of the garble. If a 4-letter group appears, add a letter to complete the 5-letter group; if a 6-letter group appears, delete the sixth letter and decipher beginning with the first garbled letter. If plain text appears after deciphering the altered group but the letters *within* that group are still garbled, begin to decipher with that group again: if a 4-letter group was found, put in the extra letter as the fourth letter of the group, then the third, etc., until a logical word appears; if a 6-letter group was found, delete the fifth letter of the group, then the fourth, etc., until a logical word appears. When the exact position for the addition or deletion of a letter is found and the plain-text equivalent for one or two letters is not definitely established from the context, consult a table of common errors in International Morse characters. If the garble was caused by deletion of a letter, examine the table for two-letter combinations commonly transmitted as one letter. If the garble was caused by addition of a letter, examine the table for letters commonly transmitted as two letters.

b. Check the group count. If one or more missing groups are indicated, advance the rotors one step for each missing letter and decipher beginning with

the first garbled group. If added groups are indicated, return to the point of the garble and decipher omitting the indicated number of groups.

c. Check for repeated groups at the point of the garble. If any, omit those groups and decipher.

d. Choose any group of the garbled text and set the converter ready to decipher it; then turn the counter up 5 more and, beginning with the chosen group, decipher groups in the order 1 and 2, 2 and 3, 3 and 4, etc., through 9 and 10, repeating groups as indicated. Do not begin within a group. If it is certain that the garble begins near the middle of a group, the error is not likely to be corrected by this procedure. The reason for this check is that one or more groups may have been lost even if the group count tallies.

e. Begin to decipher with any 5-letter group of the garbled portion of the text. Drop every third group and check for plain text after each pair of groups is deciphered. If plain text is found, return to the point of the garble, omit the proper number of groups, and complete the decipherment.

f. If the message has been transmitted by teletype, check the cipher text beyond the point of the garble for parts of plain text words. If any, apply the procedure explained in paragraph 38c (1) and (2). (A similar effect can result from the very rare case in which a rotor becomes defective and stops turning. In such a case, the message must be serviced.)

38. Short Garbles within the Body of a Message

Short internal garbles can usually be corrected by one of the procedures below.

a. If the garble is a single letter or a very few letters, set the rotors to the point of the garble, encipher pertinent letters of the probable word in their exact positions and compare the resulting cipher letters with those received to see if the difference is justified by a common transmission error or by a reversing of the order of two cipher letters in handling. If so, the assumed word is probably correct. The plain text as deciphered as well as the corrected version should be delivered to the addressee.

b. If single-letter garbles occur irregularly throughout the message, locate some of the incorrect letters and encipher in the same positions the probable plain-text letter for each. Compare each new cipher letter with the original to find whether the enciphering machine has consistently printed certain letters indistinctly. If so, substitute the correct letters throughout the cipher text for the letters which have been indistinctly printed and decipher. The following list of common substitution errors will serve as a guide in verifying assumed plain text.

Received in cipher text—	C	C	F	G	I	I	O	R	S
Correct letter —	G	O	E	Q	L	T	Q	B	B

THIS TYPE OF GARBLE WILL RARELY OC-

CUR IF THE ENCIPHERING OPERATOR REPLACES INK PADS WHEN NECESSARY.

c. If the message has been transmitted by teletype, check the garble for parts of plain-text words.

(1) *If such plain-text word parts are found, encipher probable words in their correct position and compare the resulting cipher letters with the ones received to see if the difference is explained by some incorrect position of one of the sending operator's hands. If so, replace other incorrect cipher letters on the basis of the same incorrect position of the hand, and decipher the new version of the cipher text.* For example, if a cipher letter received is J when it should have been K, K when it should have been L, I when it should have been O, etc., it will be suspected that the operator's right hand was moved one space too far to the left on the keyboard.

(2) *If no word can be determined from the partial words appearing in the garble, assume a specific incorrect position of one of the operator's hands, substitute for cipher letters which would be incorrectly received in case of that error, and attempt to decipher the new version.*

d. If there are several single-letter errors, examine the garbled message to see if the errors occur periodically. If the errors occur every 26 letters (including spaces), the first rotor was incorrectly set; if every 25 letters, the second rotor was incorrectly set; every 23 letters, the third rotor; every 21 let-

ters, the fourth rotor; every 19 letters, the fifth rotor; and every 17 letters, the sixth rotor.

EXAMPLE:

INNEED OF TWO HAMFTRACKS IMMEDIATFLY DUETOLOSS OFTSUCKS IN . . . Such a periodic error is the result of an incorrectly positioned pin. If the incorrectly positioned pin is on a rotor bearing an asterisk (*) in the effective pin and lug setting, the errors may be less frequent because the incorrectly positioned pin may not cause an error every time it comes into play. If it is necessary to find the exact pin in error, it may be determined by means of the procedure given in paragraph 2*c*, appendix IV.

CHAPTER THREE
PREVENTIVE MAINTENANCE

Section VI. PREVENTIVE MAINTENANCE TECHNIQUES

39. Meaning of Preventive Maintenance

Preventive maintenance may be defined as a systematic series of operations performed periodically on equipment in order to maintain top efficiency in performance, to minimize unwanted interruptions in service, and to eliminate major break-downs. To appreciate the meaning of the term *preventive maintenance,* it is necessary to distinguish between preventive maintenance and trouble shooting and repair. The primary function of preventive maintenance is to *prevent* major break-downs and the consequent need of repair. The primary function of trouble shooting and repair is to *locate* and *correct* existing defects. The importance of preventive maintenance cannot be overemphasized. The usefulness of an entire cipher system depends upon the mechanical efficiency of each instrument in the system. Therefore, it is vitally important that operators and repairmen of cipher machines maintain the equipment properly so that it is ready to function efficiently when needed.

40. Description of Preventive Maintenance Techniques

a. GENERAL. Many of the parts used in Converter M–209–(*) require routine preventive maintenance. Those requiring maintenance differ in the amount and kind required. Because hit-or-miss maintenance techniques cannot be applied, definite and specific instructions are needed. This section of the manual contains these specific instructions and serves as a guide for personnel assigned to perform the six basic maintenance operations, namely: Feel, Inspect, Tighten, Clean, Adjust, and Lubricate. Throughout this manual the lettering system for the six operations will be as follows:

F—Feel.*
I—Inspect.
T—Tighten.
C—Clean.
A—Adjust.
L—Lubricate.

The first two operations establish the need for the other four. The selection of operations is based on a general knowledge of field needs. For example, the dust encountered on dirt roads during cross-country travel filters into equipment no matter how much care is taken to prevent it. Without frequent inspec-

* The Feel operation is not applicable to Converter M–209–(*).

tions and the necessary performance of tightening, cleaning, and lubricating operations, equipment becomes undependable and subject to break-down when it is most needed.

b. INSPECT. Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook the evidences of minor trouble. Although these defects may not interfere seriously with the performance of the equipment, valuable time and effort can be saved if they are corrected before they lead to major break-downs. Make every effort to become thoroughly familiar with the indications of normal functioning, in order to be able to recognize the signs of defective operation. Inspection consists of carefully observing all parts of the equipment, noticing their placement, state of cleanliness, etc. Inspect for the following conditions:

(1) Placement, by observing that all accessories are mounted in their original positions.

(2) Cleanliness, by carefully examining all recesses in the units for accumulation of dust. All parts should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

(3) Tightness, by testing any shaft, rotor, or mounting which appears to be loose.

c. TIGHTEN, CLEAN, AND ADJUST. These operations are self-explanatory. Specific procedures to be

followed in performing them are given wherever necessary throughout part three.

Caution: Screws, bolts, and nuts should be tightened carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

d. LUBRICATE. Lubrication refers to the application of grease or oil to the bearings of motors or of rotating shafts. It may also mean the application of a light oil to hinges or other sliding surfaces on equipment.

41. Preventive Maintenance Items

For ease and efficiency of performance, preventive maintenance on Converter M–209–(*) will be broken down into operations that can be performed at different time intervals. In paragraphs 43 through 52, the preventive maintenance work is broken down into units of work called items. The application of the FITCAL operations in performing preventive maintenance on individual parts of Converter M–209–(*) is given under each item. Time intervals between performance of the work items are indicated on the preventive maintenance check list (par. 53).

42. Common Materials Needed

The following materials will be needed in perform-

ing preventive maintenance on Converter M–209–(*):

Clean lint-free cloth.
Compressed air or bellows.
Oil, Lubricating, Preservative, Special, (PS) U. S. Army spec No. 2–120.
Small brush for interior parts.
Screw driver.
Soap-and-water solution.
Solvent, Dry-cleaning, (SD) Federal spec No. P–S–661a.
Stiff brush for type wheel.
Tweezers.
Scrub brush for canvas carrying case

43. Item 1, Carrying Case

a. Inspect (I). (1) The canvas of the case and pockets for dirt and tears.

(2) The web carrying strap and hand strap for dirt and condition of snaps and swivels.

(3) The snap fasteners on the top flap and the pocket flap for corrosion and mechanical condition.

b. Tighten (T). Tighten the spring on the inside of the fastener opening by pressing it toward the center of the opening with a small screw driver. Tighten only if the fasteners do not close securely.

c. Clean (C). (1) Remove converter from the carrying case and all accessories from the pockets.

(2) Clean canvas carrying case and web carrying strap with a stiff brush and a hot soap-and-water solution.

(3) Clean metal snap fasteners, swivels, snaps, and **D**-rings with dry-cleaning solvent (SD).

44. Item 2, Converter Case

a. INSPECT (I). (1) Inspect the inside and outside of metal case for dirt and grease. Check for spots where the enamel finish may have been scratched or removed because of wear.

(2) Check mechanical operation of the cover-catch button and the catches for outer cover and inner lid.

(3) Check the tightness of the spring clamps which mount the accessories in the outer cover.

(4) Test mounting screws for tightness.

b. TIGHTEN (T). (1) If spring clamps do not hold accessories firmly, bend them together until a tight fit is obtained.

(2) Tighten any loose mounting screws.

c. CLEAN (C). Remove dust with a small brush. Clean spots of dirt, grease, or ink from the enameled surfaces with dry-cleaning solvent (SD).

45. Item 3, Paper-Feed Assembly

a. INSPECT (I). Check operation of paper-feed assembly to see that tape advances properly as the

machine is operated. If the tape does not feed properly, see paragraphs 74 and 75 for repair instructions.

Note. Only authorized personnel should make repairs to the converter, which involve disassembly or removal of any of the mechanical parts.

b. CLEAN (C). Clean exterior parts with a small brush or with dry-cleaning solvent (SD) if the dirt is caked. Clean interior parts with compressed air or a bellows.

c. LUBRICATE (L). Lubricate according to instructions in War Department Lubrication Order (fig. 10).

46. Item 4, Type-Wheel Assembly

a. INSPECT (I). Inspect setting knob, indicating disk, reproducing disk, and type wheel for dirt and dry, caked ink. Check mechanical operation.

b. TIGHTEN (T). Tighten the screw in the left end of the rotor shaft if it is loose.

c. CLEAN (C). Remove dirt and stains from the setting knob, indicating disk, and reproducing disk with dry-cleaning solvent (SD). If ink is caked on the type wheel, remove it with a small, stiff-bristled brush. Complete cleaning process with dry-cleaning solvent (SD).

47. Item 5, Ink-Pad Assembly

a. INSPECT (I). Examine the felt ink pad to be

sure there is sufficient ink on the pad to ink the type wheel. For instructions on replacing pads, see paragraph 32.

b. ADJUST (A). Be sure that the pin on the ink-pad holder fits into the hole in the center of the ink pad, so that the pad can rotate freely as the type wheel turns.

48. Item 6, Drum Assembly

a. INSPECT (I). (1) Inspect the assembly for dirt, rust, and corrosion.

(2) Check the mechanical operation of the drum assembly and drive. The drum lock should release, the drum should rotate smoothly, and the drum lock-arm should relock the mechanism when the converter is put through a cycle of operation.

b. CLEAN (C). Blow out loose dust or other foreign matter with compressed air or a bellows. If compressed air or a bellows is not available, brush the drum bars and disks with a small, soft-bristled brush as the drum is rotated.

Caution: Do not use rags for cleaning drum-bar lugs, gears, or other interior parts, because lint or threads from the rags may adhere to gear teeth and cause the gears to jam. This may result in damage to the converter.

c. LUBRICATE (L). Lubricate according to instructions on the War Department Lubrication Order (fig. 10).

49. Item 7, Cam and Cam-Lever Linkage

a. INSPECT (I). Check the operation of the cam and cam lever through a cycle of operation.

b. LUBRICATE (L). Lubricate according to instructions on the War Department Lubrication Order (fig. 10).

50. Item 8, Intermediate-Gear Shaft

a. INSPECT (I). Examine gears for broken or bent teeth. Report any damage to the proper authority.

b. CLEAN (C). Clean gears with a soft-bristled brush or with compressed air.

c. LUBRICATE (L). Lubricate according to instructions on the War Department Lubrication Order (fig. 10).

51. Item 9, Rotor Assembly

a. INSPECT (I). (1) Press down on intermediate-gear release arm (33) and check action of the reset knob (39).

(2) Test action of each rotor by turning with fingers.

(3) Push each rotor pin to the right and back again to the left to insure that none of them are stuck or dirty.

b. CLEAN (C). (1) Clean the rotor assembly with compressed air or a bellows.

(2) If the rotor pins need cleaning or are inoperative, remove the rotors (par. 68). Clean rotors, pins, and pin slots with dry-cleaning solvent (SD).

c. ADJUST (A). Check the rotor bearing screw to be sure it is properly fitted into the indent on the shaft, when it is replaced after lubrication (*d* below).

d. LUBRICATE (L). Lubricate according to instructions on the War Department Lubrication Order (fig. 10).

52. Item 10, Oilcan Points

LUBRICATE (L). Lubricate according to instructions on the War Department Lubrication Order.

53. Preventive Maintenance Check List

The following preventive maintenance check list is a summary of the preventive maintenance to be performed by the using organization. It provides a schedule for performing maintenance. Time intervals may be reduced at any time by the local commander. For best performance of the equipment, perform operations at least as frequently as called for on the check list. The echelon column indicates which operations are first echelon maintenance and which are second echelon maintenance. Operations are indicated by the letters I, T, C, A, L. For example, if the letters ITCA appear in the "operation"

column, the item to be treated must be inspected (I), tightened (T), cleaned (C), and adjusted (A).

Note. Gasoline will not be used as a cleaning fluid for any purpose. Solvent, dry-cleaning, is available as a cleaning fluid through established supply channels. Oil, Fuel, Diesel, may be used for cleaning purposes when dry-cleaning solvent (SD) is not on hand. Carbon tetrachloride will be used as a cleaning fluid only when inflammable solvents would constitute a fire hazard.

Caution: Carbon tetrachloride will not be used on the type-wheel assembly of Converter M–209–B because it will cause the plastic parts to disintegrate.

Item No.	Item	Operation	When performed: Daily	Weekly	256 hours	Echelon
1	Carrying case	ITC	......	x	....	1
2	Converter case	ITC	x	......	....	1
3	Paper-feed assembly	IC	x	......	....	1
3	Paper-feed assembly	ICL	......	......	x	2
4	Type-wheel assembly	ITC	x	......	....	1
5	Ink-pad assembly	IA	x	......	....	1
6	Drum assembly	I	x	......	....	1
6	Drum assembly	ICL	......	......	x	2
7	Cam and cam-lever linkage.	IL	......	......	x	2
8	Intermediate gear shaft	IC	x	......	....	1
8	Intermediate gear shaft	L	......	......	x	2
9	Rotor assembly	I	x	......	....	1
9	Rotor assembly	ICAL	......	......	x	2
10	Oilcan points	L	......	......	x	2

F	I	T	C	A	L
Feel*	Inspect	Tighten	Clean	Adjust	Lubricate

* The Feel operation is not applicable to Converter M–209–(*).

Section VII. LUBRICATION

54. War Department Lubrication Orders

War Department Lubrication Orders are waterproof, illustrated, numbered, and dated cards or decalcomania labels which prescribe approved first and second echelon lubrication instructions for mechanical equipment which requires lubrication by using organizations. Current War Department Lubrication Orders which are available are listed in the latest edition of FM 21–6, and monthly revisions thereto.

55. Requisition of War Department Lubrication Orders

Posts, camps, stations, and ports of embarkation should requisition their requirements of War Department Lubrication Orders for Signal Corps equipment in conformance with the requisitioning instructions given in FM 21–6, List and Index of War Department Publications.

56. Compliance with War Department Lubrication Orders

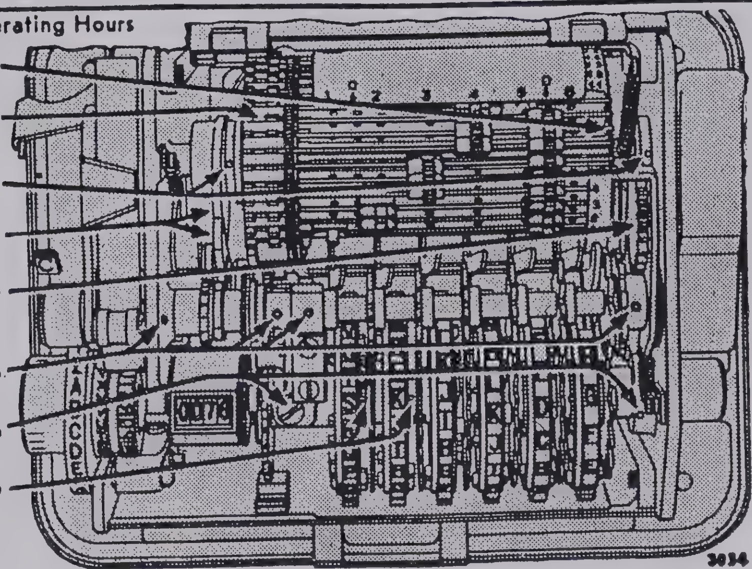
Instructions contained in War Department Lubrication Orders are mandatory and supersede all conflicting lubrication instructions of an earlier date.

WAR DEPARTMENT LUBRICATION ORDER No. 3034

WAR DEPARTMENT, WASHINGTON 25, D. C., 1 APRIL 1944

CONVERTER M-209

	Lubricant	Operating Hours
Drum Bar Slots One drop in each slot around drum.	PS	256
Drum Bar Slots Two drops in each slot around drum.	PS	256
Drum Shaft Bearings 1 or 2 drops, each	PS	256
Cam and Cam Lever Linkage Coat cam surface and lubricate lever linkage sparingly.	PS	256
Drum Gear Apply lubricant sparingly to all teeth while operating drive knob.	PS	256
Intermediate Gear Shaft 1 or 2 drops, each	PS	256
Key Wheel Shaft (Remove screw on left end) 1 or 2 drops, each	PS	256
Key Wheel One drop each end of wheel hub (Lubricate 6 wheels)	PS	256



CLEAN parts with clean lint-free cloth lightly dampened with SOLVENT, dry-cleaning. Allow parts to dry thoroughly before lubricating. Do not allow cleaning fluid to get on other parts of Converter.

OIL CAN POINTS—Every 256 hours, lubricate Enciphering and Deciphering Shaft Lock and Cam, Cover Positioning Lock, Hinges, Cover Lock and Guide Arm Pivot Shaft, Drive Knob Shaft, Pressure Arm Shaft and Keyer Lock Shaft (located below intermediate gear shaft) sparingly with PS.

DO NOT LUBRICATE—Letter Counter, Paper Feed Knob, Setting Knob and Paper Pressure Arm Roller.

REFERENCE—Technical Manual TM 11-380.

Requisition LUBRICATION ORDER from Philadelphia Signal Depot, or Utah ASF Depot, Ogden, Utah, by Signal Corps Stock No. 6D10113-34-3034

—— KEY ——

PS—OIL, lubricating, preservative, special—All air temperatures

Copy of this Lubrication Order will remain with the equipment at all times. Instructions contained therein are mandatory and supersede all conflicting lubrication instructions dated prior to 1 April 1944.

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO, *Major General,*
The Adjutant General.

TL92082

Figure 10. War Department Lubrication Order No. 3034.

Applicable War Department Lubrication Orders which are available will be obtained, carried with the equipment at all times, and fully complied with.

57. War Department Lubrication Order for Converter M–209–(*)

a. LOCATION. The War Department Lubrication Order for Converter M–209–(*) is usually placed on the rear of the outer cover.

b. FACSIMILE. Figure 10 is a facsimile of the War Department Lubrication Order for Converter M–209–(*).

58. Specific Lubricating Instructions

a. The oil rod provided with Converter M–209–(*) is attached to the cover of the oilcan and should always be used to apply oil to the machine. Apply lubricant specified on the lubrication order by dipping the oil rod into the oil in the can and applying the oil which adheres to the rod, one drop at a time, to the lubrication points (fig. 10) at intervals specified on the lubrication order (fig. 10).

b. If the rotor pins stick, place a drop of preservative lubricating oil (PS) in the rotor pin slots (fig. 12), and push the pins back and forth several times. If the rotors and pins are dirty, wash them in drycleaning solvent (SD) before lubricating the pin slots (par. 51).

c. Be sure that the oilcan cover is screwed on tightly before the oilcan is returned to its spring clamp in the converter cover. If this is not done, the oil is likely to leak out inside the converter case when the outer cover is closed.

Section VIII. MOISTUREPROOFING AND FUNGIPROOFING

59. Moistureproofing and Fungiproofing Converter M–209–(*)

Moistureproofing and fungiproofing will not be required for this equipment.

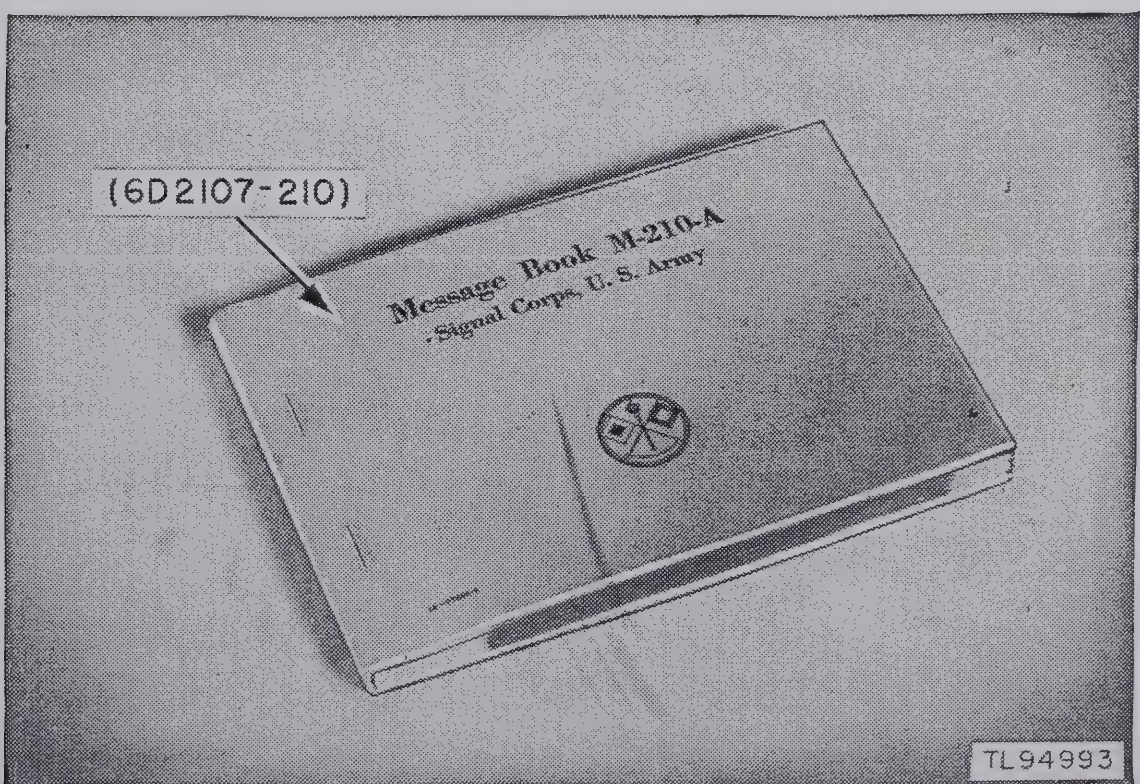


Figure 11. Message Book M–210–A.

CHAPTER FOUR
AUXILIARY EQUIPMENT

Section IX. AUXILIARY EQUIPMENT FOR CONVERTER M–209–(*)

60. Message Book (fig. 11)

a. Message Book M–210–(*) is used in handling messages enciphered on Converter M–209–(*). The message book is not a component of the equipment but two books are packed with the equipment when shipped. Books may be requisitioned as maintenance parts.

b. Message Book M–210–(*) represents Message Books M–210–A and M–210–B which are treated together in this manual.

c. Complete instructions for the use of Message Book M–210–(*) are found inside the front and back covers of the message book itself.

d. When gummed paper tape is used in Converter M–209–(*), the enciphered message may be cut into suitable lengths and pasted to the message-book blanks. If ungummed paper tape is used, the message must be copied on the blanks.

CHAPTER FIVE
REPAIR INSTRUCTIONS

Section X. THEORY OF EQUIPMENT

Note. Failure or unsatisfactory performance of equipment used by Army Ground Forces will be reported on WD AGO Form 468 (Unsatisfactory Equipment Report); and by Army Air Forces, on Army Air Forces Form 54 (Unsatisfactory Report).

61. Theory of Operation

Converter M–209–(*) operates on the cryptographic principle of reciprocal-substitution alphabets. The effect is that of sliding a normal-alphabet sequence against a reversed normal alphabet. The manner in which the various elements of the converter shift the alphabets, with respect to each other, produces a high degree of irregularity in the letter substitutions during encipherment. For example, in the enciphering of a message, the alphabets might be arranged in the following manner for the first letter:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

K J I H G F E D C B A Z Y X W V U T S R Q P O N M L

Thus, if K were the first letter to be enciphered, its

cipher equivalent would be the letter A. For the second letter to be enciphered the alphabets might be arranged as follows:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

R Q P O N M L K J I H G F E D C B A Z Y X W V U T S

If K were also the second letter to be enciphered, its cipher equivalent would be the letter H. The continual shifting of the alphabets is the factor which provides security for messages enciphered with Converter M–209–(*).

62. Rotor Assembly

a. The rotor assembly comprises the six rotors (42) with their ratchets, pawls, and gears (38); the reset knob (39) and rotor shaft; the rotor intermediate gear shaft and gears (36); and the letter counter (2). The rotor ratchet and pawl arrangement cannot be seen clearly unless the rotors are removed from the shaft. An inside view of each rotor gear is shown in figure 12.

b. The rotors are operated by the drive knob (35) on the right-hand side of the machine. The rotor gears are driven by a set of intermediate gears located behind the six rotors. A rotor feed-pawl assembly, operated by a cam on the right drum disk,

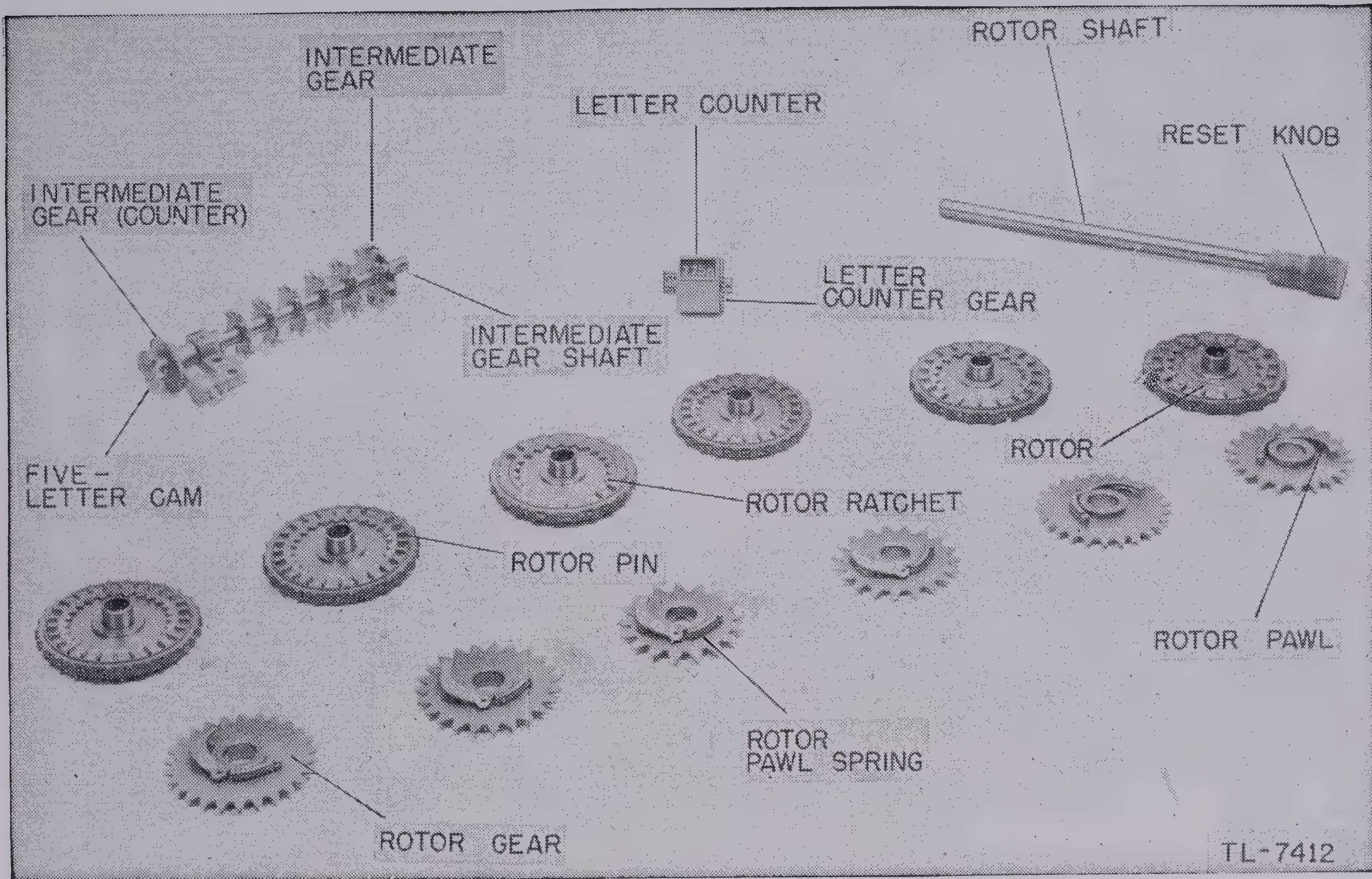


Figure 12. Rotor assembly.

moves the set of intermediate gears one notch each time the drive knob is rotated. The intermediate gears vary in circumference and number of teeth. The smallest gear has the greatest number of teeth, and is located on the left. The largest gear has the smallest number of teeth, and is located on the right. This variation is necessary because of a like variation in the rotors driven by the intermediate gears. Letters of the alphabet appear in reverse order on the outer rim of each rotor. The rotor on the left has the greatest number of letters, and the rotor on the right has the smallest number of letters (par. 9*a*). For each letter on the rotors there is one pin, and for each pin there is a tooth in the associated rotor gear. To allow the rotors to move simultaneously for one space during each operating cycle, the rotor gears are so constructed that they compensate for the differences in the spacing of the rotor pins.

c. A ratchet pawl permits turning the rotors individually by hand, but in one direction only. When the relative positions of the rotors are changed, different combinations of pins result without resetting all rotor pins.

d. The letter counter records numbers from 0000 to 9999, and is driven by a gear on the left-hand side of the intermediate-gear shaft. The counter will operate only when the rotors are turned as a unit. The reset knob will zeroize the letter counter or turn the rotors back to any previous setting.

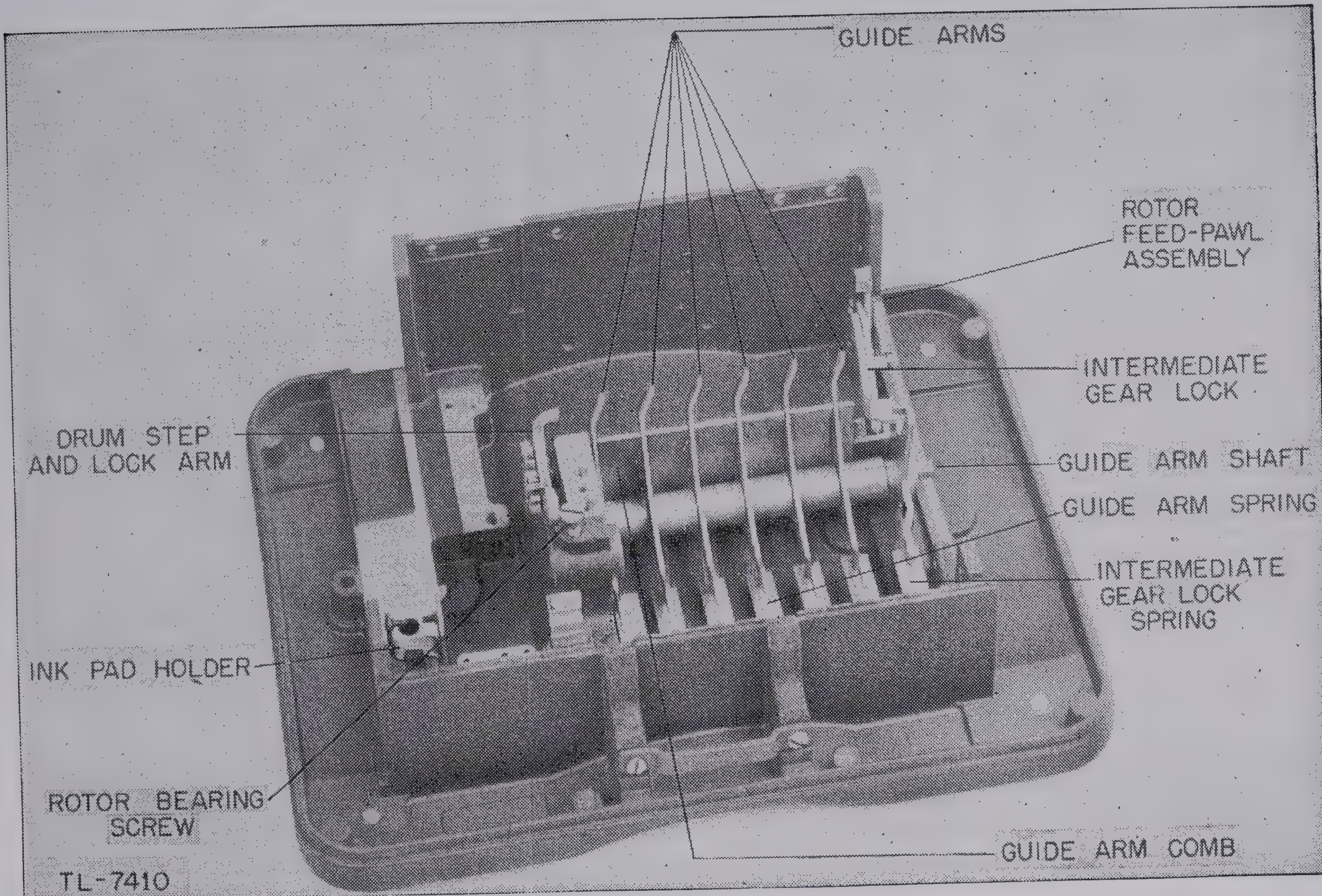


Figure 13. Guide arms.

e. A different pin on each rotor comes into play for each letter enciphered or deciphered, until the rotors have made one complete rotation. However, each rotor pin is not necessarily in an effective position. Paragraph 18*a* explains that only those pins which are pushed to the right are effective.

63. Guide Arms (fig. 13)

Six guide arms, one for each rotor, are located between the rotor assembly and the drum. The guide arms form the link between the rotors and the drum bars. When a rotor pin in the effective position comes into play, the associated guide arm is released allowing the guide-arm spring to push the guide arm toward the rear of the machine. In this position, the guide arm will, when the drum is rotated, make contact with the drum-bar lugs in line with it. For example, the guide arm for rotor number 6 will contact those lugs which are in the number 6 position on the drum bars. When the drum is turned, the guide arm forces the drum bars it controls to the left, which is their effective position. A rotor pin in the non-effective position holds the guide arm it controls in an inactive position. A guide arm held in an inactive position has no effect on the operation of the train of gears for that particular cycle.

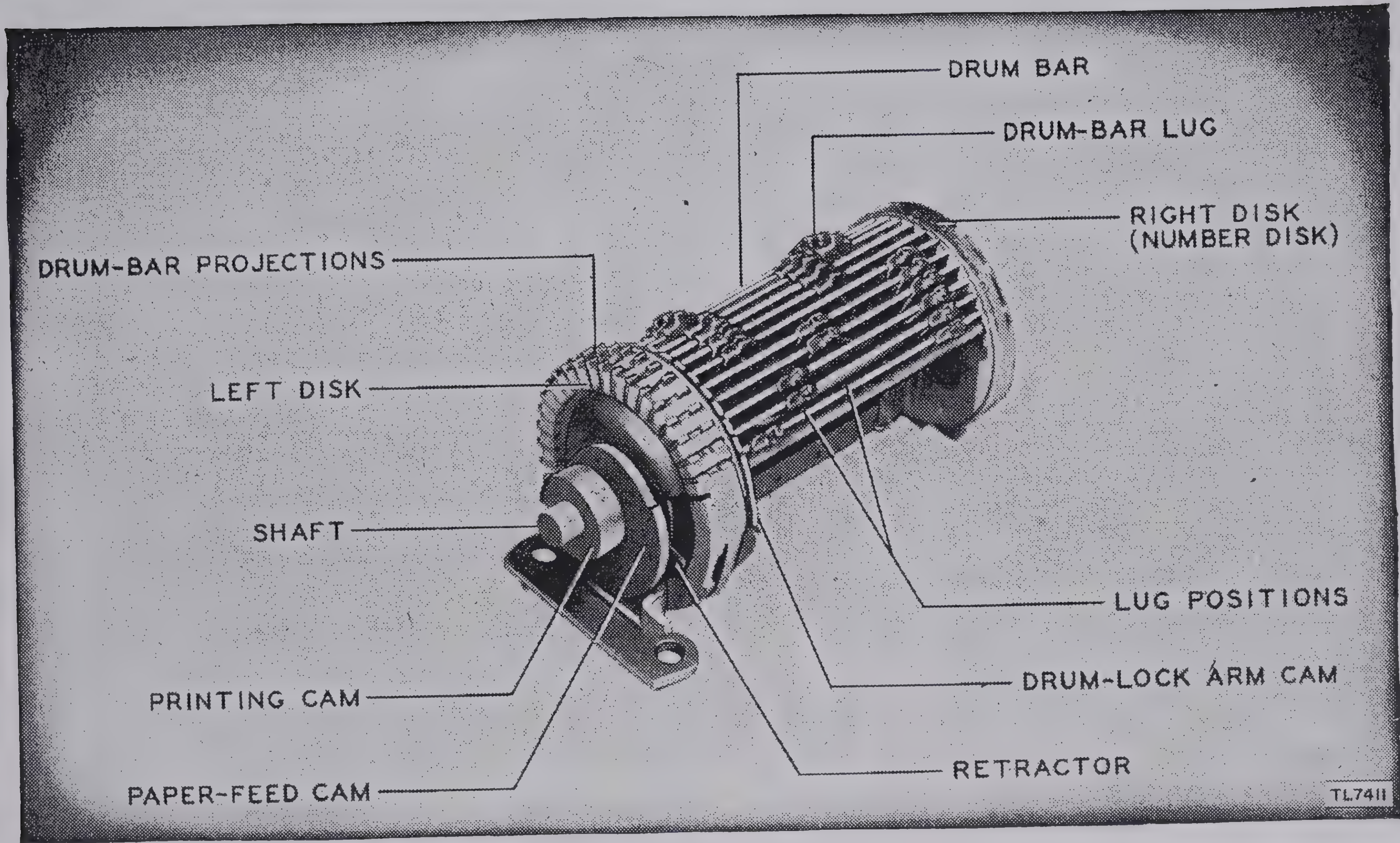


Figure 14. Drum assembly.

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64. Drum Assembly

a. The drum assembly (fig. 14) consists of the shaft and disks (30), the bars (31), and lugs (32), the step and lock arms (fig. 13), and the gear. Attached to the shaft, and operated by it, are the printing cam and the paper-feed cam. Paragraphs 65 and 66 explain the functions of the printing cam and the paper-feed cam. The 27 drum bars are numbered on a band on the right-hand drum disk to assist the operator in making the preliminary settings.

b. On each drum bar are two movable lugs. The drum-bar lugs may be moved to any one of eight positions. These eight positions are numbered (on a number plate just behind the drum assembly), in the following order: 1 0 2 3 4 5 0 6. The zero positions are noneffective, but the other six are effective positions located directly opposite the six guide arms. The lugs are placed according to the pin and lug setting in effect.

c. The drum assembly makes one complete revolution each time the drive knob is rotated, and the effective drum-bar lugs are contacted by effective guide arms. The drum-bar lugs are forced, one after the other, to the left, causing their respective drum bars to move. Projections on the left ends of the bars thus shifted act as cogs of a wheel, meshing with the type-wheel intermediate gear, which drives the type wheel. The type wheel is turned as many letters as

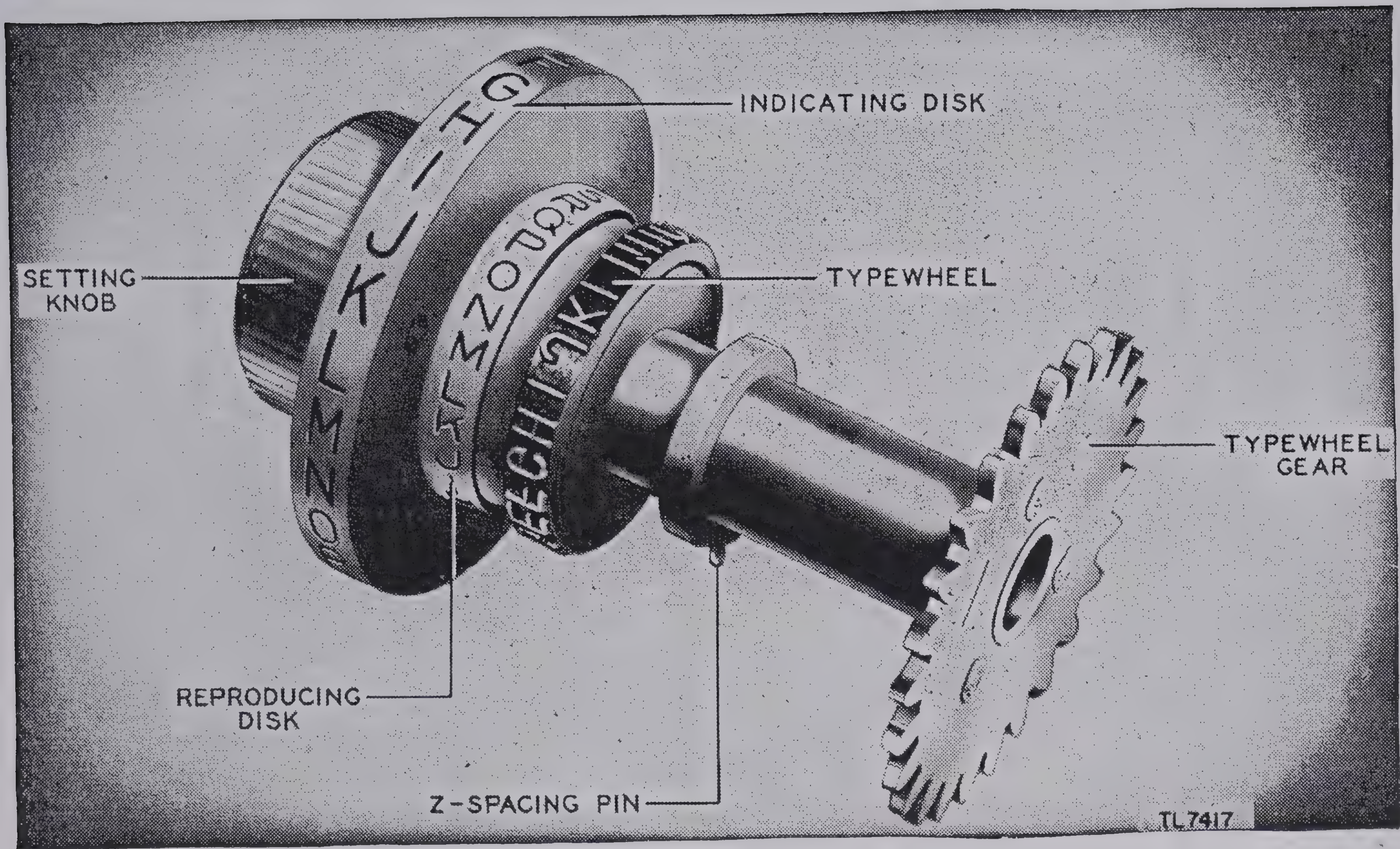

Figure 15. Type-wheel assembly.

there are bars projecting from the left of the drum. A retractor forces the bars back into neutral position after they have been used. At the end of the operating cycle, a cam on the left drum disk pushes the drum-lock arm into place; simultaneously a projection from the lock arm drops between two cogs of the type-wheel gear. The drum remains locked until the type wheel is turned, moving the projection of the lock arm, and releasing the lock arm.

65. Type-wheel and Print-arm Assemblies

a. The setting knob (8), indicating disk (7), reproducing disk (6), type wheel (5), and type-wheel gear (43), are all mounted on a common shaft and make up the type-wheel assembly (fig. 15). A screw in the end of the shaft holds the type-wheel assembly in place. The assembly is used to select the letter to be enciphered or deciphered and to print the resultant letter on a paper tape.

b. The indicating disk, containing the letters of the alphabet in normal order, is set to the desired letter by alinement of that letter with the indicating index (3) on the inner lid. During the operating cycle, the type-wheel intermediate gear meshes with the effective drum bars and drives the type-wheel gear. The type wheel prints the letter in position at the end of the cycle; printing is accomplished through the action of the print hammer. The letter

printed may also be seen as the first letter visible on the reproducing disk. If the supply of tape or ink pads should become exhausted, the cipher text or clear text may be copied from the reproducing disk, one letter after each operating cycle.

c. The print-arm assembly is mounted on the shaft of the encipher-decipher knob and includes the print arm, print hammer, and print-arm stop. A spring attached to the print arm and the base of the converter keeps the required tension on the assembly.

d. Printing is accomplished at the end of each operating cycle, when the printing cam (fig. 14) on the drum shaft allows the print arm to be pulled forward suddenly by the print-arm spring. The print hammer, a piece of hard rubber clamped in the teeth of the print arm, strikes the tape against the inked type wheel, printing a letter. The printing cam, continuing its cycle, brings the print arm back to its original position.

e. The print-arm stop prevents printing of the letter Z when the machine is being used to decipher. A cam on the shaft of the encipher-decipher knob controls the operation of the print-arm stop. When the encipher-decipher knob is set in the D position, the encipher-decipher cam pushes the print-arm stop forward and holds it. On the type-wheel shaft there is a small pin offset from the letter Z, which rests against the print-arm stop when Z is to be printed. As a result, the print hammer is not allowed to strike

the type wheel and a blank space appears on the tape. When the encipher-decipher knob is set in the C position, the print-arm stop is held back and does not touch the pin.

66. Paper-feed Assembly

a. The paper-feed assembly consists of a large cam on the drum shaft (fig. 14), an arm which rides on this cam, a pawl and ratchet, a small five-letter cam (13), a paper-feed stop, and a knob (fig. 16).

b. The revolution of the paper-feed cam causes the paper-feed arm to move the paper-feed pawl and ratchet one notch for each operating cycle, advancing the paper tape one space. Double spacing between groups is accomplished by the five-letter cam. A projection from the paper-feed arm rides on the outer rim of the five-letter cam, which has two indentations on opposite sides. As the projection rides into one of the indentations, the paper-feed arm moves the pawl and ratchet two notches, advancing the tape two spaces. After five letters have been enciphered, the projection will again ride into an indentation on the cam and permit double spacing.

c. Automatic spacing is not desired during deciphering, and is prevented by the paper-feed stop. The paper-feed stop is in contact with the cam of the encipher-decipher knob. When the encipher-decipher knob is set in the D position, the arm of

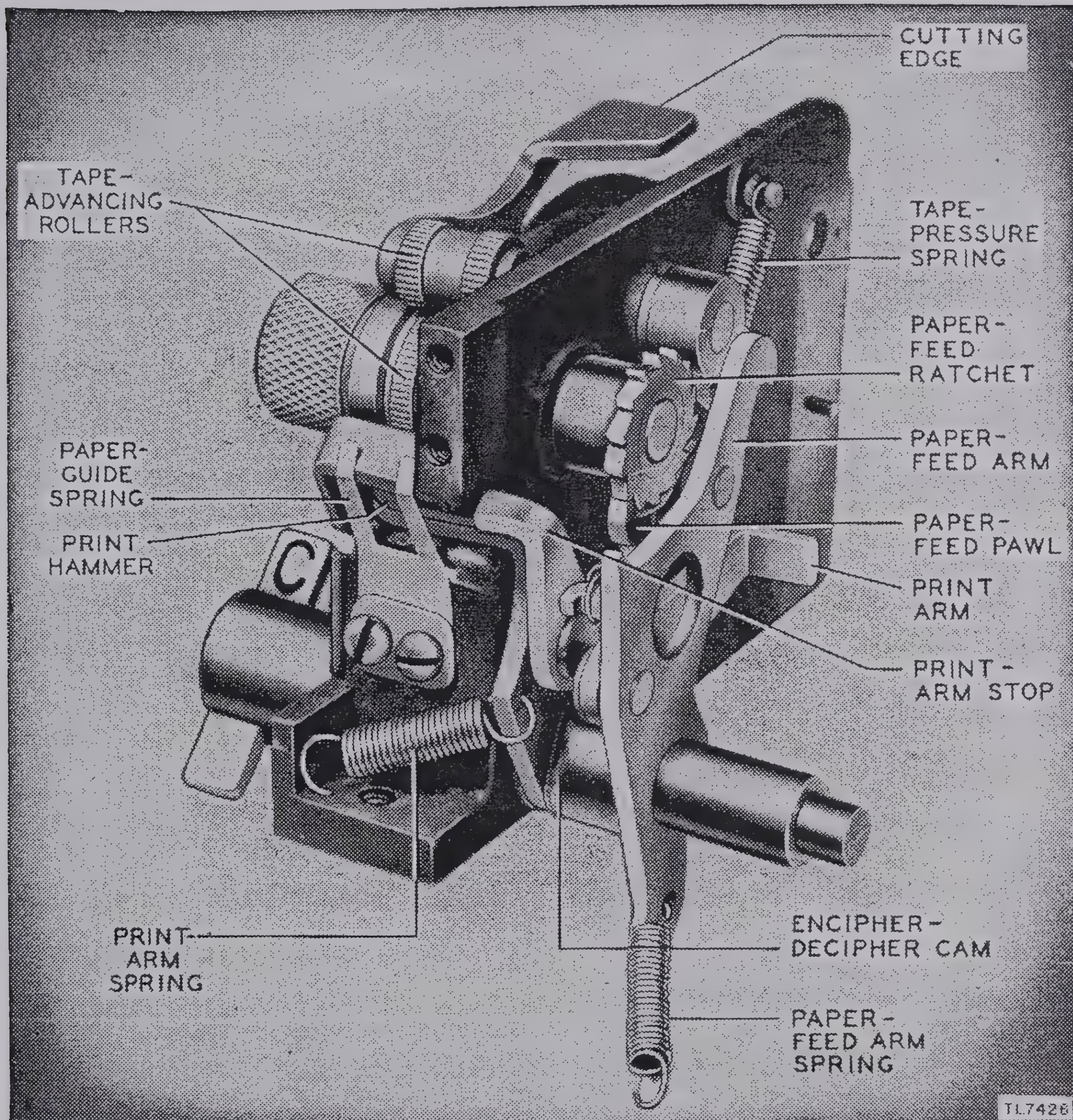

Figure 16. Paper-feed assembly.

the paper-feed stop is raised and alined on a fixed projection of the drum-shaft bracket. The projection of the paper-feed arm is prevented from following the contour of the five-letter cam, resulting in continuous single spacing.

Section XI. Minor Repairs

67. General Instructions

a. Operators should be careful when servicing or making minor repairs on the Converter M–209–(*). Many of the interior parts may become bent if improper tools or careless maintenance procedures are used. If drum bars, guide arms, or other parts are bent, they will cause the machine to jam or to operate incorrectly.

b. Operators not trained in making minor repairs should not attempt any repair on Converter M–209–(*).

c. An operator who has been trained in these repair procedures may make certain minor repairs in order to keep the machine in operation. Paragraphs 69 through 76 explain the common minor troubles and include information for correcting such troubles. Paragraph 68 explains how the operator may partially disassemble the machine, and limits repairs which he may perform, to minor ones. All other repairs must be made by second echelon or higher repair personnel.

d. Use only screw drivers and pliers of the proper size when making minor repairs or adjustments on the mechanical parts of the equipment.

e. Tighten mounting and assembly screws snugly, but do not overtighten them. Some of the screws

are made of soft metal and the threads will strip easily, if the screws are tightened too much.

68. Dismantling for Minor Repair

Converter M–209–(*) can be sufficiently dismantled to enable the operator to make any necessary minor repairs, as follows:

a. Remove ink pad by moving the pad holder to the front and moving pad to the right and up with tweezers.

b. Remove letter counter (two screws). Be careful not to lose the shims which are used behind the counter mounting on some converters.

c. Remove rotor shaft as follows:

(1) Loosen screw in the left end of the rotor shaft only.

(2) Loosen rotor-shaft bearing screw (fig. 13).

(3) Remove rotor shaft (fig. 12) by pulling the reset knob (with the screw still in it) to the right, while rocking the rotors with the palm of the left hand.

d. Remove type-wheel assembly (fig. 15) by moving the ink-pad holder toward the front of the converter and then moving the type-wheel assembly slightly to the left and up.

e. Remove rotors (fig. 12) by lifting up and out. Start with the first rotor on the left and proceed in order toward the right.

f. To remove rotor gear and ratchet pawl from rotor, hold the rotor firmly, then grasp the rotor gear and pull straight out from the rotor.

69. Jamming

a. DESCRIPTION AND LOCATION. Converter M–209–(*) is jammed when the drive knob will not revolve. Jamming may occur at any phase of an operating cycle and is generally the result of faulty operation. DO NOT USE FORCE IN AN ATTEMPT TO CLEAR THE MACHINE. The operator should first make the following checks to locate the cause of the trouble:

(1) Move indicating disk slightly and realine letter to be enciphered or deciphered. Try drive knob.

(2) Move reset knob until it snaps into place (if not already in place). Try drive knob.

(3) Open inner lid. Rock drum back and forth several times. Try drive knob.

b. CAUSES. If none of the checks listed clears the jam, the operator must determine whether the trouble is due to one of the following causes:

(1) *Drum-bar lug out of line, bent drum-bar lug, or bent drum-bar projection* (fig. 14). Open the inner lid. If the drum has been moved through only part of the operating cycle, proceed as follows:

(*a*) Using the flat side of the screw driver, push to the right, drum bars projecting beyond the left

side of the drum. The drum bars must be pushed until flush with left side of the drum.

(*b*) Turn drive knob until it locks.

(*c*) Check for a lug not fitted into a hole. Check also for a bent lug, or for a bent drum-bar projection.

(*d*) If a lug or projection is bent, straighten it with a pair of long-nose pliers and use it until a new lug or bar can be obtained.

(2) *Bent guide arm* (fig. 13). Check each guide arm to determine if one is bent and touching a drum bar or the base of a drum-bar lug. If a bent guide arm is found, pull it back toward the front of the machine, and turn the drive knob to complete the cycle. Bend the guide arm back to its proper position with a pair of pliers. The guide arm must make contact with the side of the lug projection only. Do not bend the guide arm into the comb (fig. 13), or the guide arm will not operate freely.

(3) *Excessive play in rotors.* Open the inner lid. Check each rotor to determine whether one has slipped to the right and become disengaged from the rotor intermediate gear (fig. 12). Rotors slip as a result of the loosening of the right-hand shaft screw or of the rotor bearing screw (fig. 13). Re-engage the rotor gear, and tighten the right-hand shaft screw and the rotor bearing screw until the rotors have no play to the left or right. It may be necessary to tap two or three times on the end of

the reset knob before tightening the screws in order to slide the shaft over to its proper location.

Caution: When tightening the rotor bearing screw, do not use too much pressure. The screw is made of very soft metal and is easily broken.

(4) *Bent type-wheel detent.* The type-wheel detent is located below and slightly toward the rear of the type-wheel gear. The type-wheel detent rides on the type-wheel gear and makes the clicking noise heard when the setting knob is turned. If the type-wheel detent becomes bent to either side of the type-wheel gear, the entire mechanism of the converter may jam. Raise the inner lid and remove the letter counter (par. 68*b*). If the type-wheel detent is bent, bend it back to the proper position, and turn the drive knob. See paragraph 81*i* for information on replacing the letter counter.

70. Minor Rotor Repairs

a. ROTORS STICK. Rotors operating sluggishly or sticking in intermediate positions probably are set too tightly on the shaft. Check the rotor bearing screw to determine whether it has been properly set in the indent on the shaft. If not, slide the shaft until the screw is fitted into the indent. If the rotors continue to stick, the converter must be serviced by a repairman.

b. ROTOR PINS STICK. See Paragraph 51.

71. Minor Guide-Arm Repairs

A guide arm may become bent at the point where it runs through the guide-arm comb (fig. 13). If a guide arm is bent it may operate sluggishly or may not become effective at the proper time, due to scraping against the side of the comb. Adjust the guide arm by bending with a pair of long-nose pliers. Be certain not to bend any other part of the guide arm.

72. Minor Drum-Assembly Repairs

a. Drum Bars Stick. If the drum bars stick, lubricate each of the drum-bar slots on the left-hand drum disk (fig. 14) according to instructions on the War Department Lubrication Order (fig. 10).

b. Drum Not Locking. Bend the projection from the drum-lock arm (fig. 13), so that the projection rides on the cam on the left drum disk when an operating cycle is completed. If the trouble is not corrected, the converter must be serviced by a repairman.

73. Minor Type-Wheel-Assembly Repairs

If the indicating disk turns hard, check for one of the following troubles:

a. Insufficient Space on Rotor Shaft. Check the rotor bearing screw to determine that it is properly fitted into the indent on the shaft. If not, slide the shaft until the screw fits.

b. LOCKING ARM NOT RELEASING PROPERLY. The projection of the drum-lock arm, which locks the type-wheel gear, should fit snugly between the cogs of the gear. Adjust the locking arm by bending to the proper position.

c. BENT TYPE-WHEEL DETENT. See paragraph 69*b*(4).

d. LACK OF OIL ON SHAFT (fig. 12). Lubricate according to instructions on the War Department Lubrication Order (fig. 10).

74. Improper Printing

a. WEAK OR MISSING PRINT-ARM SPRING (fig. 16). If the spring is weak, shorten it and use it until another spring is available.

b. MISALINEMENT OF PRINT HAMMER. If the rubber pad which is mounted in the print arm becomes oil-soaked or worn on one side, it will fail to print properly. To remove the pad from the print arm, remove the type-wheel assembly, the paper-guide spring, and the hammer guard (fig. 16). Next loosen the clamps on the hammer and lift out the pad. Trim the pad until it is smooth, or turn it end for end, and replace it in the clamps. (Proper size of the print hammer is 7/32-inch long, 5/32-inch wide, and 3/32-inch thick.) Do not clamp the pad too tightly or the outer surface will become rounded.

c. SPRUNG PAPER-GUIDE SPRING (fig. 16). If

sprung, bend the side of the paper-guide spring which is out of line, until both sides of the spring apply an equal amount of pressure to the tape. When adjusting the paper-guide spring, remember that the print hammer must fall between the two arms of the spring.

d. Sprung Ink-Pad Holder. This trouble may result in the printing of only a part of a character. Bend the holder into its proper shape and use it until a new holder can be obtained.

75. Improper Feeding of Paper Tape

The paper tape may feed improperly, or cease to feed, due to one of the following causes:

a. Clogging of Tape at Rollers (fig. 16). The tape will clog when improperly inserted between the rollers (either placed in crooked or not reaching to the end of the paper-pressure arm), or when stuck to the rollers. Remove the clogged tape and insert the end of the tape between the rollers, advancing it to the end of the paper-pressure arm. If gummed tape is used and continues to stick, try turning the tape over so that printing appears on the gummed side.

b. Flattened Roller. Regroove the roller with a sharp instrument.

c. Weak Paper-Pressure-Arm Spring (fig. 16). This spring is located on the inside of the left side-

plate, toward the rear of the machine. Shorten the weak spring to provide sufficient tension, until a new spring is available.

d. MISALINEMENT OF PAPER-PRESSURE ARM. This trouble will cause the paper tape to move out of line and become clogged in the sides of the rollers. Bend the arm until the two rollers are properly fitted.

e. MISSING PAPER-FEED ARM SPRING (fig. 16).

76. Improper Counting

The letter counter will not operate correctly if improperly mounted. Follow the directions for mounting the counter as given in paragraph 81*i*. The counter will be inaccurate if a tooth is broken off either the letter-counter gear (fig. 12), or the intermediate gear which meshes with the letter-counter gear.

77. Operator's Trouble Chart

The following chart should aid the operator in locating and correcting minor troubles encountered in the operation of Converter M–209–(*). In this chart common troubles are listed under the heading "Symptom" and are described as the trouble affects the operation of the machine. Probable causes and corrective measures to be applied are given or referred to in the second and third columns of the chart.

Symptom	Cause	Correction
a. Drive knob will not turn (jamming).	1. Reset knob out of place.	1. Turn knob until it clicks.
	2. Bent drum-bar lug or drum-bar projection.	2. Bend to correct shape with long-nose pliers.
	3. Drum-bar lug not fitted into hole.	3. Fit properly.
	4. Bent guide arm.	4. See paragraph 69*b*(2).
	5. Excessive play in rotors.	5. See paragraph 69*b*(3).
	6. Bent type-wheel detent.	6. See paragraph 69*b*(4).
b. Improper printing.	1. Broken or bent paper-guide spring.	1. See paragraph 74*c*.
	2. Print hammer worn or misalined.	2. See paragraph 74*b*.
	3. Sprung ink-pad holder.	3. See paragraph 74*d*.
c. Failure to print.	1. No ink on pad.	1. See paragraph 32.
	2. Weak or broken print-arm spring.	2. See paragraph 74*a*.

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Symptom	Cause	Correction
d. Indicating disk turns hard.	1. Binding on rotor shaft.	1. See paragraph 73*a*.
	2. Locking arm bent and not releasing properly.	2. See paragraph 73*b*.
	3. Bent type-wheel detent.	3. See paragraph 69*b*(4).
	4. Lack of lubrication.	4. See paragraph 73*d*.
e. Paper tape feeds improperly.	1. Tape clogged in rollers.	1. See paragraph 75*a*.
	2. Flattened roller.	2. Regroove the roller.
	3. Weak pressure-arm spring.	3. See paragraph 75*c*.
	4. Paper-pressure arm out of line.	4. See paragraph 75*d*.
	5. Paper-feed arm spring detached or broken.	5. Connect properly.
f. Improper counting.	1. Incorrectly mounted letter counter.	1. See paragraph 76.
	2. Broken tooth on counter gear or intermediate gear.	2. Send to repair echelon.

Section XII. DISASSEMBLY AND REPLACEMENT OF PARTS

78. Repair Procedures

a. Repairmen should be careful when servicing and repairing Converter M–209–(*). Many of the interior parts are likely to become bent if improper tools are used or if the repairman is careless in handling his tools. If drum bars, guide arms, or other parts are bent, they will cause the machine to jam or to operate incorrectly.

b. Use screw drivers and pliers of the proper size for the particular application, when replacing, repairing or adjusting mechanical parts of the equipment.

c. Tighten mounting and assembly screws snugly, but do not overtighten them. Some of the screws are made of soft metal and the threads will strip easily if the screws are tightened too much.

d. Be careful not to lose any of the small parts when disassembling and reassembling mechanical parts of the equipment.

e. When installing a new part or reassembling parts which have been disassembled, be sure that all gears mesh properly and that other parts are in correct mechanical relationship with each other.

79. Common Mechanical Failures

a. GENERAL. It is impracticable to list all of the failures possible with Converter M–209–(*). A summary of some of the more common mechanical failures is given below as a check list for the repairman, including those which have already been discussed under the operator's "minor repair" headings.

b. CHECK LIST FOR REPAIRMEN. (1) Defective rotor feed, allowing rotors to remain stationary.

(2) Too much play in rotors on shaft.

(3) Binding rotors.

(4) Binding type-wheel assembly.

(5) Jamming of lock on type-wheel gear teeth.

(6) Inoperative drum lock, that is, drum moves past stop.

(7) Drum out of line due to previous jam cleared by force.

(8) Sprung drum bar.

(9) Bent or burred drum-bar projection.

(10) Bent drum-bar lug.

(11) Sticking of drum bar.

(12) Failure in operation of intermediate-gear lock.

(13) Partial advancement of rotors due to bind in rotor feed pawl.

(14) Irregular or binding paper feed.

(15) Weaving of paper tape.

(16) Guide arms binding irregularly, or sticking in active or inactive positions.

(17) Weak, detached, or broken spring on paper-feed pawl.

(18) Irregular printing due to broken or bent paper-guide spring.

(19) Irregular printing due to worn or loose print hammer.

(20) Failure to print due to weak or broken print-arm spring.

(21) Sprung ink-pad holder.

(22) Broken rotor-pawl ratchet spring.

(23) Rotor pawl slipped out of ratchet.

(24) Rotor pin sticking.

(25) Failure of type-wheel detent (safety catch) to function properly.

(26) Detached or broken type-wheel detent spring.

(27) Improper counting.

80. Procedure for Dismantling

If a converter requires more than minor repair it must be serviced by a repairman. In addition to the dismantling procedure authorized an operator (par. 68), a repairman will continue dismantling as follows:

a. Remove the drum-bar-lug number plate as follows:

(1) Release the drum lock and rotate the drum by turning the drive knob until 27 on the number band is the only number visible.

(2) Remove the two screws which mount the number plate to the rear frame. (Be careful not to lose spacing washer behind plate on left mounting screw.)

(3) After removal of the number plate, complete the drum cycle.

b. Turn the converter on its side and remove the screw under the base that holds the spring and detent ball in place for the encipher-decipher knob.

c. Remove the left side-plate, proceeding as follows:

(1) Unhook the print-arm spring and the paper-feed arm spring from the spring clip (fig. 16).

(2) Remove the screw at the lower rear of the left side-plate.

(3) Remove the screw at the upper rear of the left side-plate. (This screw mounts the cover-latch assembly.)

(4) Remove the screw in the inset on the underside of the base.

(5) Remove the side-plate by moving it to the left, being careful not to bend or break the dowel pin on the rear of the left side-plate.

d. Remove the guide-arm shaft as follows:

(1) Push on the right end of the shaft with a small screw driver, forcing the shaft out to the left.

(2) Remove the guide arms and the intermediate-gear lock from left to right.

e. Remove the intermediate-gear shaft and gears.

(1) Unhook the type-wheel-gear detent spring from the spring clip.

(2) Loosen the intermediate-gear-shaft bearing-bracket mounting screws. Lift bearing bracket up, being careful of the dowel pin.

(3) Remove the shaft and gears by pulling to the left.

f. Remove the drum assembly according to the following procedure:

(1) Unhook the intermediate-gear step-arm spring from the spring clip on the back of the frame at the upper right.

(2) Loosen the two mounting screws (lower left end of drum assembly).

(3) Hold the intermediate-gear step-arm assembly toward the front and lift the left end of the drum assembly slightly, being careful not to bend or break the dowel pin. Then remove the drum assembly by pulling to the left and up.

g. To remove a drum bar, lift the left end of the bar slightly and move it to the extreme left. Grasp

the right end of the drum bar and swing it up; at the same time move the left end of the bar out from under the drum-bar retaining spring.

81. Reassembly

a. Replace the drum assembly as follows:

(1) Hold the intermediate-gear step-arm assembly toward the front of the converter and insert the drum assembly. Be sure the rear end of the drive knob is slightly above the front end when the drive knob is rotated until it locks.

(2) Rehook the intermediate-gear step-arm spring.

(3) Replace the mounting screws (lower left end of drum assembly).

b. Replace the intermediate-gear shaft; then rehook the type-wheel-gear detent spring to the spring clip.

c. Replace the guide arms and intermediate-gear lock as follows:

(1) Note that all guide arms are numbered either 156 or 234. Place any guide arm numbered 156 in the first position on the guide-arm shaft (counting from left to right).

(2) Follow the guide arm numbered 156 with the three guide arms numbered 234.

(3) Place on the shaft the remaining two guide

arms numbered 156, and place the intermediate-gear lock (fig. 13) in the extreme right position.

(4) Feed the guide-arm shaft through the guide arms as they are placed in position from left to right. The smaller end of the shaft is inserted in the lower bearing in the rotor bracket, and the bent ends of the guide arms are placed through the slots in the guide-arm comb. Each guide arm must rest on a part of the flat spring. The intermediate-gear lock rests on its own spring. Then adjust for freedom of movement and alinement. Adjustments may be made by loosening the three screws holding the guide-arm comb in place, and sliding the comb back and forth until the proper alinement is obtained. If necessary, a guide arm which scrapes against the comb may be adjusted by bending it with a pair of long-nose pliers. Bend only that portion of the guide arm which operates in the slots of the comb.

d. Replace the left side-plate; then rehook the print-arm spring and paper-feed arm spring to the spring clip.

e. Replace the encipher-decipher knob detent ball and spring.

f. Replace the rotors as follows:

(1) Insert the rotor shaft through the hole in the right side-plate so the shaft reaches the position for rotor number 6.

(2) Each rotor is numbered according to its

position with the exception of number 6, which is blank. The numbers are visible through a hole in the rotor gear and are engraved on the rotor pawl. (The number of teeth on the rotor gears corresponds to the number of letters on the rotor with which it works.) Place rotor number 6 in position and slide the shaft through it. Follow with each rotor in reverse order, that is, 5, 4, 3, 2, 1.

(3) Slide the shaft through the rotors *as far as the rotor-shaft bearing,* then proceed to the next step in *g* below.

g. Replace the type-wheel assembly as follows: After the rotor shaft has passed through the rotors from right to left as far as the rotor-shaft bearing, place the type-wheel assembly in line with the rotor shaft. Hold the type-wheel-gear detent out of engagement with the gear. Then pass the rotor shaft completely through the type-wheel assembly. Push the reset knob against the rotors until they fit closely together in place and tighten the rotor bearing screw. Use care, as this screw breaks easily. Replace the screw in the left end of the rotor shaft. Test the type wheel and rotors to determine if they turn freely. A certain amount of play is permissible for the type wheel, but no play is allowable for the rotors.

h. Replace the drum-bar-lug number plate.

i. Replace the counter. Before mounting, the counter must be set to 0000 or any multiple of five.

The five-letter cam must be properly positioned to assure coordination between the cam and the counter. Proper positioning is accomplished by turning the drive knob a sufficient number of times to bring the dowel pins of the intermediate-gear shaft to a vertical position. The counter gear must mesh properly with its intermediate gear, so that a full series of numbers is visible through the letter-counter window.

j. Replace the ink pad.

82. Inspection Check

The following check list should be used after repairs and adjustments have been completed by the repairman. This inspection will insure that the machines are returned to service in proper working condition. Check each item in the list for the faulty conditions and make corrections if necessary before returning Converter M–209–(*) to service.

Condition	Correction
a. ENCIPHER-DECIPHER KNOB.	
(1) Knob binds	Realine left side-plate.
(2) No detent in knob	Install new detent.
b. LETTER COUNTER.	
(1) Faulty alinement of numbers.	Position five-letter cam properly.
(2) Gears out of line	See paragraph 81*i*.
(3) Gears not meshing properly.	Add or take off shims.
c. DRUM.	
(1) Drum jams	Check position of drum-bar lugs.
(2) Sprung drum bar	Install new bar. (Reverse procedure in par. 80*g*.)
(3) Drum bar sticks	Clean slot or replace bar.
(4) Drum lock inoperative	Adjust drum, check lock spring.
(5) Drum binding	Check alinement.
(6) Drum slips when intermediate lock is open.	Check intermediate-gear release arm assembly.
(7) Drum-bar number band loose.	Tighten screws at each end of band.
d. DRUM-BAR LUGS.	
(1) Lugs too loose or too tight.	Adjust.
(2) Lugs improperly fitted in drum-bar holes.	Set correctly.

Condition	Correction
e. GUIDE ARMS.	
(1) Too weak or too strong...	Adjust guide-arm spring.
(2) Too far from or too close to rotors.	Adjust by bending.
(3) Guide arms stick, causing improper encipherment and decipherment.	Adjust by bending.
(4) Improperly adjusted to lugs on drum.	Adjust by bending.
(5) In wrong position..................	Check guide-arm numbers (par. 81*c*).
f. INTERMEDIATE-GEAR SHAFT. ASSEMBLY.	
(1) Intermediate-gear lock arm riding on drum.	Adjust by bending.
(2) Counter intermediate gear making contact with drum-bar projection.	Position drum properly.
(3) Faulty alinement of gears.	Aline properly.
(4) Improper timing of rotor feed pawl.	Adjust intermediate-gear lock by bending.
g. PAPER FEED.	
(1) Defective cam or loose taper pin.	Repair or replace.
(2) Defective paper	Replace with new roll.
(3) Paper jams in rollers.........	Clear wadded paper and advance tape.

Condition	Correction
(4) Paper feeds crookedly	Adjust paper-pressure roller.
(5) Paper feed inoperative	Check entire assembly.
h. Rotor Pins.	
(1) Pins stick	Clean and lubricate (pars. 51 and 58*b*).
(2) No detent	Replace rotor.
i. Rotors.	
(1) Defective	Replace.
(2) Excessive side play	Tighten right-end screw on rotor shaft; remove shim, if necessary.
(3) Rotors in wrong positions.	Change to right positions.
(4) Rotors not alined	Aline correctly.
(5) Defective ratchet	Replace rotor.
(6) Binding; difficult to move.	See paragraph 70*a*.
j. Rotor Gears.	
Gear bent	Straighten if possible; otherwise replace.
k. Rotor Release.	
(1) Intermediate-gear release arm sticks.	Check tension of positioning spring. Clean and lubricate intermediate-gear release arm. (See oilcan point on intermediate-gear shaft on lubrication order, fig. 10.)

Condition	Correction
(2) Inoperative reset button	Check reset-button spring and intermediate-gear release arm.
l. PRINTING.	
(1) Double print	Aline print hammer.
(2) Poor lettering	Aline print hammer; check centering of ink pad in holder.
(3) Poor letter spacing	Check paper feed.
(4) Letter Z printed with machine set to decipher.	Check pin on type-wheel shaft.
(5) Letter groups irregular	Check intermediate-feed arm on right of drum.
(6) Letters appear in groups of 10, 15, or 20, but not 5.	Check paper-feed assembly.
m. SCREWS.	
(1) Loose	Tighten.
(2) Marred	Replace.
(3) Missing	Insert new screws.
n. SPRINGS.	
(1) Deformed	Replace.
(2) Missing	Insert new springs.
(3) Detached	Fasten properly.
o. TYPE WHEEL.	
(1) Binding	Adjust (par. 73*a*). If binding continues, add shims under left-end shaft screw.

Condition	Correction
(2) Type-wheel detent stiff...	Check type-wheel detent spring.
(3) Excess play on rotor shaft.	Adjust (par. 73*a*).
(4) Type-wheel gear riding on letter-counter shaft.	Adjust position of letter counter.
(5) Inoperative type-wheel lock.	Check drum alinement.
(6) Lock jamming on gear teeth.	Check drum alinement.
p. WASHERS.	
Missing	Use new washers.

83. Unsatisfactory Equipment Report

a. When trouble in equipment used by Army Ground Forces occurs more often than qualified repair personnel feel is normal, WD AGO Form 468 (War Department Unsatisfactory Equipment Report) will be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by Army Air Forces occurs more often than qualified repair personnel feel is normal, AAF Form 54 will be filled out and forwarded to the Commanding General, Air Matériel Command, Wright Field, Dayton, Ohio, in accordance with AAF Regulation 15–54.

APPENDIX I

MAINTENANCE PARTS

The appropriate pamphlet of the Signal Supply Catalog for Converter M–209–(*) is SIG 7 & 8 M–209, Organizational and Higher Echelon Spare Parts.

For an index of available catalog pamphlets, see the latest issue of Signal Supply Catalog SIG 1 & 2.

Note. Maintenance parts will be requisitioned through normal supply channels and not direct from the Chief Signal Officer.

APPENDIX II

PREPARATION OF PIN AND LUG SETTINGS

1. Pin Settings

a. Prepare a table of the rotors by listing, in alphabetical order, the letters appearing on the face of each rotor: the first rotor, A to Z; the second rotor A to Z, omitting W; the third rotor A to X, omitting W; the fourth rotor A to U; the fifth rotor A to S; and the sixth rotor A to Q.

b. Prepare a set of 156 cards, 78 of which are marked R (right) and the remainder L (left). Shuffle the cards thoroughly and draw one at a time. Start with A on rotor number 1, and prepare the key list in accordance with the cards drawn: If a card bears an L, cross out the letter; if a card bears an R, do not cross out the letter. Only letters with effective pins are then shown in the setting (tables I and IV). More than six consecutive effective or noneffective pins on any rotor must be rearranged in order to prevent use of such a sequence. A random arrangement, in which from 40 to 60 percent of the pins are in the effective position, is assured by this method.

2. Lug Settings*

To prepare a table of favorable lug settings, proceed with the following steps in the order given:

a. SELECTION OF NUMBERS. Select a set of six numbers from either group A or group B (pars. 1 and 2, app. III). Sets of numbers selected from group B must not exceed 10 percent of the total sets selected. The sets are selected at random from the table. Sets of numbers from group B should be used at irregular intervals and should not succeed each other in key lists.

b. REARRANGEMENT OF NUMBERS. Rearrange the numbers so that they appear in random order. Each number indicates the number of lugs to be placed in one of the effective positions on the drum. Lug placements may be randomized in each column as long as the necessary overlaps are obtained and all other requirements met.

c. DISTRIBUTION OF OVERLAPS. Although there are two lugs on each bar, the bar can be moved to the left only once for each rotation of the drive knob. When both lugs of the same bar are in effective positions, the condition is described as an overlap. The total number of overlaps produced by a given set of numbers is found by subtracting 27 (the number of bars on the drum) from the sum of the six numbers

* This discussion presupposes a thorough understanding of paragraphs 63 and 64*c*.

in that set. The number of overlaps required for each set of numbers has been calculated, and is given with the sets (pars. 1 and 2, app. III). The following rules offer a general guide for distributing the overlaps (some deviation may be made from all except the rule in (4) below, which must always be observed):

(1) Most of the six positions on the drum should be involved in the overlaps.

(2) Overlaps should occur between positions which are separated and between positions which are side by side.

(3) A small number of overlaps should occur between several positions rather than a large number of overlaps between only two positions.

(4) There will *never* be more than four overlaps between any two positions. It is permissible, however, for a position to have a combined overlap of more than four. (Position 5 in table III has a combined overlap of 5.)

Note. When all the lugs in a particular position on the drum are overlapped, the condition is described as a *complete overlap*. Column 2 in table III illustrates a complete overlap. During one rotation of the drive knob, bars 6 and 7 may both be moved by the operation of either rotor 2 or 5 or by rotors 2 and 5 operating together. Thus when an effective pin on rotor 5 comes into play, rotor 2 can have no additional effect upon the process of encipherment. For this reason, the 26-letter check cannot insure that all the pins on rotor 2 are

correctly set, and the rotor must be checked independently. *Do not avoid* the use of a complete overlap in lug settings; the occasional use of settings of this type adds to the security of the system. It is not advisable, however, to have more than one position on the drum completely overlapped in any setting. Whenever a setting contains a complete overlap, an asterisk will be placed beside the number of the corresponding rotor in the pin setting, directing attention to a footnote which warns the operator to "check this rotor thoroughly." (The symbol (*) is used in this manual.)

d. CHECKING PLACEMENT OF OVERLAPS. The overlaps must be so placed that a single number (representing the number of lugs in a given position on the drum) or the sum of any two, three, four, five, or all six of the numbers, yields all the values from 1 to 27, inclusive. Remember that the result of two effective lugs on the same drum bar is one. For example, in table III there are seven effective lugs in column 6, and eight effective lugs in column 5, giving a total of fifteen. However, two of the effective lugs are on one bar; thus the effect of one lug is canceled, yielding a result of only fourteen. Hence, the proper total for columns 5 and 6 is fourteen (eight plus seven minus one) and not fifteen.

e. PREPARING LUG SETTING WORK SHEET. The effective lugs (represented by X's) are now entered on a work sheet similar to that shown in table III; lugs in the same column are placed on successive drum bars in as many cases as the overlap condition permits. (If the overlap condition makes it necessary

or more convenient to place the lugs on bars which are separated, it is permissible to do so.) The completed work sheet should be checked carefully for accuracy with the results of the previous steps. The zero positions need not be shown on this chart.

f. PREPARING LUG SETTING TABLE. Convert the lug positions set up on the work sheet to a form similar to that illustrated in table IV, by writing the numbered positions of the lugs opposite the number representing the drum bar. Determine the positions by referring to the number plate (29) at the rear of the drum-bar cage.

g. COMPLETE PREPARATION OF LUG SETTING. The following example serves to illustrate the preparation of a lug setting. The steps are numbered to correspond to the steps described in *a* through *d* above.

(1) Select a set of numbers from group A.
1, 2, 4, 7, 8, 11 Overlaps = 6

(2) Rearrange the numbers.
11, 2, 4, 1, 8, 7

(3) Distribute the overlaps.

Positions:

1	2	3	4	5	6
11	2	4	1	8	7

(*a*) Five of the six positions are involved.

(*b*) Positions side by side: Positions separated:

Positions side by side	Positions separated
5 and 6	1 and 6
	2 and 5
	3 and 5

(*c*) A small number of overlaps occur between several positions rather than a large number of overlaps between only two positions.

(*d*) Overlaps between any two positions do not exceed four.

(4) All values from 1 to 27, inclusive, are obtained. For example:

1 is given by position 4
2 is given by position 2
3 is given by positions 2 and 4
4 is given by position 3
5 is given by positions 3 and 4
6 is given by positions 2 and 3, and so on.

3. Purpose

The foregoing limitations are imposed to provide the greatest amount of security possible in the shifting of the alphabets, and to add to the difficulties of enemy cryptanalysts engaged in making a mathematical analysis of the messages.

Table III. Position of drum-bar lugs work sheet

	1	2	3	4	5	6
1.				X		
2.			X			
3.			X			
4.			X		X	
5.			X		X	
6.		X			X	
7.		X			X	
8.					X	
9.					X	
10.					X	
11.					X	X
12.						X
13.						X
14.						X
15.						X
16.						X
17.	X					X
18.	X					
19.	X					
20.	X					
21.	X					
22.	X					
23.	X					
24.	X					
25.	X					
26.	X					
27.	X					

Table IV. Suggested form for publishing keying information contained in tables I and II

(SAMPLE) PIN AND LUG SETTING
(Effective date)

Drum-Bar Lug Setting: Drum Bar	Drum-Bar Lug Setting: Lug Position	Rotor Pin Setting (Pins on letters listed below are to be placed to the right. All others are to be placed to the left.)					
1	0–4	1	2*	3	4	5	6
2	3–0	A	A	A	—	—	A
3	3–0	B	—	B	—	B	B
4	3–5	—	—	—	C	—	—
5	3–5	D	D	—	—	D	D
6	2–5	—	E	—	E	E	—
7	2–5	—	—	—	F	F	—
8	0–5	—	G	G	—	—	—
9	0–5	H	—	H	H	H	H
10	0–5	I	—	—	I	I	—
11	5–6	—	J	J	—	—	—
12	0–6	K	K	—	—	—	K
13	0–6	—	L	L	—	—	—
14	0–6	M	—	M	M	M	—
15	0–6	N	—	N	N	N	N
16	0–6	—	O	—	—	—	O
17	1–6	—	—	—	P	P	—
18	1–0	—	—	—	—	—	Q
19	1–0	—	R	R	—	—	
20	1–0	S	S	S	S	S	
21	1–0	T	—	T	T		
22	1–0	—	U	U	U		
23	1–0	V	—	—			
24	1–0	W	X	X			
25	1–0	—	—				
26	1–0	—	—				
27	1–0	—					

26-Letter Check:
NIHTZ DXAJJ KVSIT HKNKO NAGZR I

* Check this rotor thoroughly. An error in setting the pins on this rotor may not appear in the 26-letter check but will appear as an error in the message; therefore, it is important that the operator check the position of each pin on this rotor to insure its conforming to the position shown in this pin setting.

The indicator for this "Pin and Lug Setting" is VC.

APPENDIX III

SETS OF NUMBERS AND OVERLAPS FOR LUG SETTINGS

I. Group A

Sets						Overlaps	Sets						Overlaps
1	2	3	4	9	10	2	1	2	4	5	7	11	3
1	2	3	4	8	11	2	1	2	4	5	6	12	3
1	2	3	4	7	12	2	1	2	4	6	8	9	3
1	2	3	4	6	13	2	1	2	4	6	7	10	3
1	2	3	5	8	10	2	1	2	3	4	10	11	4
1	2	3	5	7	11	2	1	2	3	4	9	12	4
1	2	3	5	6	12	2	1	2	3	4	8	13	4
1	2	3	6	8	9	2	1	2	3	5	9	11	4
1	2	3	6	7	10	2	1	2	3	5	8	12	4
1	2	4	5	8	9	2	1	2	3	5	7	13	4
1	2	4	5	7	10	2	1	2	3	6	9	10	4
1	2	4	5	6	11	2	1	2	3	6	8	11	4
1	2	4	6	7	9	2	1	2	3	6	7	12	4
1	2	3	4	9	11	3	1	2	3	7	8	10	4
1	2	3	4	8	12	3	1	2	4	5	9	10	4
1	2	3	4	7	13	3	1	2	4	5	8	11	4
1	2	3	5	9	10	3	1	2	4	5	7	12	4
1	2	3	5	8	11	3	1	2	4	5	6	13	4
1	2	3	5	7	12	3	1	2	4	6	7	11	4
1	2	3	5	6	13	3	1	2	4	6	8	10	4
1	2	3	6	8	10	3	1	2	4	7	8	9	4
1	2	3	6	7	11	3	1	2	3	4	10	12	5
1	2	3	7	8	9	3	1	2	3	4	9	13	5
1	2	4	5	8	10	3	1	2	3	5	10	11	5

Sets						Overlaps
1	2	3	5	9	12	5
1	2	3	5	8	13	5
1	2	3	6	9	11	5
1	2	3	6	8	12	5
1	2	3	6	7	13	5
1	2	3	7	9	10	5
1	2	3	7	8	11	5
1	2	4	5	9	11	5
1	2	4	5	8	12	5
1	2	4	5	7	13	5
1	2	4	6	9	10	5
1	2	4	6	8	11	5
1	2	4	6	7	12	5
1	2	4	7	8	10	5
1	2	3	4	11	12	6
1	2	3	4	10	13	6
1	2	3	5	10	12	6
1	2	3	5	9	13	6
1	2	3	6	10	11	6
1	2	3	6	9	12	6
1	2	3	6	8	13	6
1	2	3	7	9	11	6
1	2	3	7	8	12	6
1	2	4	5	10	11	6
1	2	4	5	9	12	6
1	2	4	5	8	13	6
1	2	4	6	8	12	6
1	2	4	6	9	11	6
1	2	4	6	7	13	6
1	2	4	7	9	10	6
1	2	4	7	8	11	6
1	2	3	4	11	13	7
1	2	3	5	11	12	7

Sets						Overlaps
1	2	3	5	10	13	7
1	2	3	6	10	12	7
1	2	3	6	9	13	7
1	2	3	7	10	11	7
1	2	3	7	9	12	7
1	2	3	7	8	13	7
1	2	4	5	10	12	7
1	2	4	5	9	13	7
1	2	4	6	8	13	7
1	2	4	6	9	12	7
1	2	4	6	10	11	7
1	2	4	7	9	11	7
1	2	4	7	8	12	7
1	2	4	8	9	10	7
1	2	3	5	11	13	8
1	2	3	6	11	12	8
1	2	3	6	10	13	8
1	2	3	7	10	12	8
1	2	3	7	9	13	8
1	2	4	5	11	12	8
1	2	4	5	10	13	8
1	2	4	6	9	13	8
1	2	4	6	10	12	8
1	2	4	7	10	11	8
1	2	4	7	9	12	8
1	2	4	7	8	13	8
1	2	4	8	9	11	8
1	2	3	5	12	13	9
1	2	3	6	11	13	9
1	2	3	7	11	12	9
1	2	3	7	10	13	9
1	2	4	5	11	13	9
1	2	4	6	10	13	9

Sets						Overlaps	Sets						Overlaps
1	2	4	6	11	12	9	1	2	4	7	10	13	10
1	2	4	7	10	12	9	1	2	4	8	9	13	10
1	2	4	7	9	13	9	1	2	4	8	10	12	10
1	2	4	8	10	11	9	1	2	3	7	12	13	11
1	2	4	8	9	12	9	1	2	4	6	12	13	11
1	2	3	6	12	13	10	1	2	4	7	11	13	11
1	2	3	7	11	13	10	1	2	4	8	11	12	11
1	2	4	5	12	13	10	1	2	4	8	10	13	11
1	2	4	6	11	13	10	1	2	4	7	12	13	12
1	2	4	7	11	12	10	1	2	4	8	11	13	12

2. Group B

Sets						Overlaps	Sets						Overlaps
1	1	2	4	9	12	2	1	2	2	5	8	11	2
1	1	2	4	8	13	2	1	2	2	5	7	12	2
1	1	2	5	9	11	2	1	2	2	5	6	13	2
1	1	2	5	8	12	2	1	2	2	6	10	11	2
1	1	2	5	7	13	2	1	2	2	6	7	11	2
1	1	3	4	9	11	2	1	2	3	3	9	11	2
1	1	3	4	8	12	2	1	2	3	3	8	12	2
1	1	3	4	7	13	2	1	2	3	3	7	13	2
1	1	3	5	9	10	2	1	2	3	5	5	13	2
1	1	3	5	8	11	2	1	2	3	5	9	9	2
1	1	3	5	7	12	2	1	2	3	6	6	11	2
1	1	3	5	6	13	2	1	2	3	7	7	9	2
1	1	3	6	8	10	2	1	2	4	4	7	11	2
1	1	3	6	7	11	2	1	2	4	4	5	13	2
1	2	2	3	9	12	2	1	2	4	5	5	12	2
1	2	2	3	8	13	2	1	1	2	4	9	13	3
1	2	2	4	9	11	2	1	1	2	5	10	11	3
1	2	2	4	7	13	2	1	1	2	5	9	12	3
1	2	2	5	9	10	2	1	1	2	5	8	13	3

Sets						Overlaps
1	1	3	4	10	11	3
1	1	3	4	9	12	3
1	1	3	4	8	13	3
1	1	3	5	9	11	3
1	1	3	5	8	12	3
1	1	3	5	7	13	3
1	1	3	6	9	10	3
1	1	3	6	8	11	3
1	1	3	6	7	12	3
1	2	2	3	9	13	3
1	2	2	4	10	11	3
1	2	2	4	9	12	3
1	2	2	4	8	13	3
1	2	2	5	9	11	3
1	2	2	5	8	12	3
1	2	2	5	7	13	3
1	2	2	6	9	10	3
1	2	2	6	8	11	3
1	2	2	6	7	12	3
1	2	3	3	10	11	3
1	2	3	3	9	12	3
1	2	3	3	8	13	3
1	2	3	4	10	10	3
1	2	3	6	6	12	3
1	2	3	6	9	9	3
1	2	3	7	7	10	3
1	2	4	4	9	10	3
1	2	4	4	8	11	3
1	2	4	4	7	12	3
1	2	4	4	6	13	3
1	2	4	5	5	13	3
1	2	4	5	9	9	3
1	2	4	6	6	11	3

Sets						Overlaps
1	2	4	7	7	9	3
1	1	2	5	10	12	4
1	1	2	5	9	13	4
1	1	3	4	10	12	4
1	1	3	4	9	13	4
1	1	3	5	10	11	4
1	1	3	5	9	12	4
1	1	3	5	8	13	4
1	1	3	6	9	11	4
1	1	3	6	8	12	4
1	1	3	6	7	13	4
1	2	2	4	9	13	4
1	2	2	5	10	11	4
1	2	2	5	9	12	4
1	2	2	5	8	13	4
1	2	2	6	9	11	4
1	2	2	6	7	13	4
1	2	3	3	10	12	4
1	2	3	3	9	13	4
1	2	3	5	10	10	4
1	2	3	6	6	13	4
1	2	3	7	7	11	4
1	2	3	7	9	9	4
1	2	4	4	9	11	4
1	2	4	4	7	13	4
1	2	4	6	9	9	4
1	2	4	7	7	10	4
1	1	2	5	10	13	5
1	1	3	4	10	13	5
1	1	3	5	10	12	5
1	1	3	5	9	13	5
1	1	3	6	10	11	5
1	1	3	6	9	12	5

Sets						Overlaps
1	1	3	6	8	13	5
1	2	2	4	10	13	5
1	2	2	5	10	12	5
1	2	2	5	9	13	5
1	2	2	6	9	12	5
1	2	2	6	8	13	5
1	2	3	3	10	13	5
1	2	3	4	11	11	5
1	2	3	6	10	10	5
1	2	3	7	7	12	5
1	2	4	4	10	11	5
1	2	4	4	9	12	5
1	2	4	4	8	13	5
1	2	4	6	6	13	5
1	2	4	7	7	11	5
1	2	4	7	9	9	5
1	2	4	8	8	9	5
1	1	3	5	11	12	6
1	1	3	5	10	13	6
1	1	3	6	10	12	6
1	1	3	6	9	13	6
1	2	2	4	11	13	6
1	2	2	5	11	12	6
1	2	2	5	10	13	6
1	2	2	6	9	13	6
1	2	3	3	11	13	6
1	2	3	5	11	11	6
1	2	3	7	7	13	6
1	2	3	7	10	10	6
1	2	4	7	7	12	6
1	2	4	8	9	9	6
1	1	3	5	11	13	7
1	1	3	6	11	12	7
1	1	3	6	10	13	7
1	2	2	4	12	13	7
1	2	2	5	11	13	7
1	2	2	6	11	12	7
1	2	2	6	10	13	7
1	2	3	6	11	11	7
1	2	4	4	11	12	7
1	2	4	4	10	13	7
1	2	4	5	11	11	7
1	2	4	7	7	13	7
1	2	4	7	10	10	7
1	2	4	8	8	11	7
1	1	3	6	11	13	8
1	2	2	6	11	13	8
1	2	3	5	12	12	8
1	2	4	4	11	13	8
1	2	4	6	11	11	8
1	1	3	6	12	13	9
1	2	2	6	12	13	9
1	2	3	6	12	12	9
1	2	4	4	12	13	9
1	2	4	5	12	12	9
1	2	4	7	11	11	9
1	2	4	8	8	13	9
1	2	2	6	13	13	10
1	2	3	5	13	13	10
1	2	4	8	11	11	10
1	2	3	6	13	13	11
1	2	4	7	12	12	11
1	2	3	7	13	13	12

APPENDIX IV

SUPPLEMENTARY INFORMATION ON GARBLES

1. Incorrectly Alined Rotor

The following explanation and examples will illustrate some types of situations which result when one rotor is incorrectly alined when encipherment of the message text begins.

a. Note the following encipherment:

```
SUCCCUSFUJ LCPBGLGBBMADEAT NQINTXROIGPQ...
```

Examination of these letters shows recognizable plain text, and some of the correct letters can be assumed and filled in:

```
     S
SUCCCUSFUJ LCPBGLGBBMADEAT NQINTXROIGPQ...
    E    L
```

The first word may be assumed to be SUCCESSFUL. Note that when the correct letters are supplied in this word those letters are uniformly two intervals (or two letters) from the incorrect letters in the normal alphabet; that is, E is two letters from

C in the normal alphabet, S two letters from U, and L two letters from J.

b. In order to ascertain whether this two-letter interval is uniform throughout the garbled text of the message, try to reconstruct the remainder of the text, thus:

```
           JANZEJEZZKYBCYRLOGLRVPMGENO
SUCCESSFUL LCPBGLGBBMADEATNQINTXROIGPQ . . .
           NERDINTDDOCFGCVPSKPVZTQKIRS
```

The message is found to read: SUCCESSFUL LANDING MADE AT POINT ROGERS . . . It is only necessary to read enough of a message to establish the interval existing between the incorrect letters and the corresponding correct letters in the normal alphabet. As soon as this interval is established, the rotor which was incorrectly alined can easily be identified as follows: If the incorrect letters are one letter removed from the correct ones in the normal alphabet, find the position (on the drum) which has only one lug; the rotor in error will be the rotor associated with that position. For example, if there is one lug in position No. 4 (as in table IV), then rotor No. 4 is the one which was erroneously positioned in alining the message rotor alinement on the rotors. Likewise, if the incorrect letters on the tape are two letters removed from the correct ones in the normal alphabet, and if there are two lugs in position No. 2, then rotor No. 2 is the one which was erroneously alined, etc.

c. The characteristics may sometimes be slightly different from those shown by the example above. Note the following garbled text:

```
HIGHTAY FRFHDH OOUTLOF PKINTC
    W

          T
ORCIRSVDESXROYEA
               D
```

The words HIGHWAY and DESTROYED are recognizable. When the correct letters are supplied in these words, intervals are established as follows: W is three letters removed from T in the normal alphabet, and D is three letters from A; but T is four letters removed from X. It will be seen that the interval between the incorrect and the correct letters is not always constant: in the example the incorrect letters are sometimes *three,* sometimes *four* letters removed from the correct ones. Now test the second word:

```
        B  D
        C  E E
        D  F F
        E  G G
HIGHTAY FRFHDH . . .
    U     G E
    V     H F
    W     I G
```

(The second word is found to be BRIDGE.)

Enough words have now been revealed to determine which rotor was erroneously alined by the enciphering operator. *If two different intervals are involved* (in this example, 3 and 4), *always use the larger number to determine the rotor in error.* In the example, if there are four lugs in position No. 3 (as in table IV), rotor No. 3 was erroneously alined.

d. Once the incorrectly alined rotor is determined, try the probable errors on that particular rotor. For example, if the message rotor alinement is JGLBCH and rotor No. 2 has been erroneously alined, try F, then H, the letters before and after G on the rotor. If these attempts at correction are unsuccessful, assume an error due to indistinct printing and substitute C for G. If plain text is not produced, try each letter on the rotor as the starting letter.

Note. Partial plain text with incorrect letters one interval from correct letters will result in the rare case of a lug error which has not affected the message rotor alinement. (See par. 36*m* and par. 3, app. IV.)

2. Incorrectly Positioned Pin

For the more experienced operators the following will be helpful. An incorrectly positioned pin on either the enciphering or the deciphering machine yields an incorrect letter in approximately one-half the 12-letter results coming from that machine, thereby giving incorrect message rotor alinements in most of these.

a. The three types of incorrect message rotor alinements which can result from an incorrectly positioned pin are illustrated below.

Type 1

Correct 12-letter result: UIJYS OWGBZ RI
Incorrect 12-letter result: UIJYN OWGBZ RI
Correct message rotor alinement: UIJSOG
Incorrect message rotor alinement: UIJNOG

This type of error gives one incorrectly alined rotor. The clue for the deciphering clerk in discovering and correcting this type of error is the appearance of fragments of plain-text words on the tape. The clue will not always be present, however. When parts of plain-text words appear, this type of error may be corrected by means of steps given in paragraph 1, app. IV, except for periodic single-letter errors which will still remain in the text; if necessary, the exact pin causing these errors may be found by means of the procedure given in *c* below.

Type 2

Correct 12-letter result: UIJYS OWGBZ RI
Incorrect 12-letter result: UIJYX OWGBZ RI
Correct message rotor alinement: UIJSOG
Incorrect message rotor alinement: UIJOGB

In the example used to illustrate a "Type 1 error," both the correct letter S and the incorrect letter N can be used as the fourth letter of the message rotor

alinement, because both N and S appear on the fourth rotor. Therefore, only one letter of the message rotor alinement is wrong. But note that in the example of a "Type 2 error," the S of the *correct* 12-letter result appears on the fourth rotor, whereas X of the incorrect 12-letter result does *not* appear on the fourth rotor and must be eliminated in forming the message rotor alinement. Therefore, three letters of the message rotor alinement are affected, causing three rotors to be erroneously alined. A "Type 2 error" can cause as many as five incorrect letters in the message rotor alinement. This type of error may be corrected by means of the procedure given in paragraph 36*k* except for periodic single-letter errors which will still remain in the text; if necessary, the exact pin causing these errors may be found by means of the procedure given in *c* below.

Type 3

Correct 12-letter result: UIJYS OWGBZ RI
Incorrect 12-letter result: UIJTS OWGBZ RI
Correct message rotor alinement: UIJSOG
Incorrect message rotor alinement: UIJTSO

Note that the incorrect letter T appears in the 12-letter result instead of the correct letter Y. Y does not appear on the fourth rotor but T does appear. Therefore, three letters of the message rotor alinement are made incorrect. A "Type 3 error" can also

cause as many as five incorrect letters in the message rotor alinement. Correction is usually more difficult than for the other types. To test for a "Type 3 error," check the 12-letter result and note all letters which must be omitted in deriving the message rotor alinement. (If none, this type of error did not occur.) Replace the first of these letters with an A, derive a new message rotor alinement, and decipher several groups from it. Check the tape for fragments of plain-text words or phrases. If none are found, replace the A with some other letter and try once more. Two trials should yield some plain text if the rotor concerned is in error. If the second trial is unsuccessful, return to the *original* 12-letter result, substitute A for the second letter which would normally be omitted, and repeat the process. When partial plain-text words are found, the same message rotor alinement should be tried again but with the A replaced by B, then by C, then D, etc., until the message begins to decipher properly except for periodic single-letter errors; if necessary, the exact pin causing these errors may be found by means of the procedure given in subparagraph *c* below.

b. If the deciphering operator could know that a pin on the enciphering machine was wrong and had yielded an incorrect message rotor alinement, and could also know which rotor contained the incor-

rectly positioned pin, he could decipher the message by following the procedure explained in subparagraphs (1) through (5) below. In spite of the warning note, "Check this rotor thoroughly," a pin error is most likely to occur on a rotor marked with an asterisk (*) in the pin and lug setting, that is, on a rotor corresponding to a drum position having all its lugs overlapped (complete overlap, see note, par. 2*c* (4) app. II). This being true, the operator may check the drum for such a position and if one is found, assume the corresponding rotor to contain an incorrectly positioned pin. To decipher the message proceed as follows:

(1) Set up the message indicator with the counter at 0000; turn the reset knob until the pin (on the rotor assumed to be in error) then in position to control the guide arm comes to the bench mark: for rotor No. 1, this will be at the counter reading 0015; for rotor No. 2, 0014; for rotor No. 3, 0013; for rotor No. 4, 0012; for rotor No. 5, 0011; for rotor No. 6, 0010. Turning the reset knob as explained will bring to the bench mark on the rotor concerned, the *only* pin on that rotor which had any effect on the first letter of the 12-letter result. The next pin above it is the only pin on that rotor which had any effect on the second letter of the 12-letter result, etc.

(2) Change the pin brought to the bench mark,

and a fixed number of pins above it, to the opposite position; that is, if the pin is to the left, place it to the right, and vice versa. Since the letter in error could not have been one of the letters discarded at the end of the 12-letter result, the number of pins to be reversed need be only 6, the number of letters alined on the rotors, plus the number of letters eliminated (in deriving the message rotor alinement) because they do not appear on the rotors.

(3) Having reversed the proper number of pins, reset to the message indicator and encipher the system indicator once for each reversed pin.

(4) NEXT, CHANGE THE PINS BACK TO THEIR CORRECT SETTING.

(5) The first letter of the result obtained will be that used by the enciphering operator if the first pin was wrong; therefore, substituting that letter in the 12-letter result yields the same 12 letters the enciphering operator would have derived. If the message cannot be deciphered from the resulting message rotor alinement, then the pin concerned was not at fault, and the next letter is substituted, etc., as illustrated below. Note that when the letter is identical with that in the message rotor alinement, as in the second, fifth, sixth, and seventh positions in the example below, no change is necessary.

Example:

12-letter result —XSYSJ FGLIS BL

Cipher result obtained in step (3) —V~~S~~AQ~~J~~ ~~FG~~

New 12-letter results —VSYSJ FGLIS BL

XSASJ FGLIS BL

XSYQJ FGLIS BL

(6) When plain text results, periodic single-letter errors will appear within the deciphered text because of the incorrectly positioned pin. If it is necessary to reverse the pin causing the error, it may be done by means of the procedure given in *c* below.

c. To correct an incorrectly positioned pin when the rotor containing it is known and the message rotor alinement is *not* affected, apply the following procedure: Set the converter ready to decipher the first incorrect letter. Then advance the rotors 15 steps if the incorrectly set pin was on rotor No. 1, 14 steps if it was on rotor No. 2, 13 steps for rotor No. 3, 12 steps for rotor No. 4, 11 steps for rotor No. 5, and 10 steps for rotor No. 6. The incorrect pin will then be at the bench mark and may be reversed.

3. Lug Errors

If one lug of the enciphering operator's converter was misplaced and the deciphering operator has succeeded in correcting the message rotor alinement

(par. 36*m*), the following procedure will enable him to determine the drum position containing the misplaced lug and to move a lug which will produce complete plain text. For examples of the types of errors caused by a misplaced lug, see paragraph 36*m*.

a. Set the converter ready to decipher the first incorrect letter; note which guide arms are pushed toward the rear of the converter.

b. Set the converter ready to decipher the second incorrect letter and note which guide arms are pushed toward the rear.

c. Continue this process until one of the guide arms pushed to the rear is found to be common to these operations (that is, pushed to the rear each time). The drum position associated with that guide arm contains the lug which was misplaced on the enciphering converter. Make a note of the position found.

d. Examine the garbled text.

(1) If the incorrect letters on the tape immediately follow the correct letters in the alphabet ("Type 1 error," par. 36*m*), a lug which should have been effective was moved to a noneffective position on the enciphering converter.

(2) If the incorrect letters immediately precede the correct letters in the alphabet ("Type 2 error," par. 36*m*), a lug which should have been noneffective was made effective.

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e. If the lug was moved from an effective to a noneffective position, proceed as follows. Having determined which guide arm is pushed to the rear every time an error occurs, set the converter ready to decipher, in turn, each correct letter. Note whether the guide arm concerned is ever pushed to the rear.

(1) If the guide arm is *not* pushed to the rear, the misplaced lug was on a bar having the other lug of that bar in the noneffective position. Examine the drum position known to contain the misplaced lug. Any lug in that position which is on a bar having the other lug in the noneffective position may be moved to the other noneffective position, and the message can be deciphered.

(2) If the guide arm *is* pushed to the rear, the misplaced lug was on a bar having the other lug of that bar in an effective position. Examine the drum position known to contain the misplaced lug. Any lug in that position which is on a bar having the other lug in an effective position may be moved to the noneffective position; if the drum position containing the misplaced lug is overlapped with more than one position, it may be necessary to try moving, in turn, a lug in each case in which the other lug is in a *different* effective drum position.

f. If the lug was moved from a noneffective position to an effective position, proceed as follows:

(1) Set the converter ready to decipher, in turn,

each correct letter and note which guide arm is always pushed to the rear at the same time as the previously determined guide arm (*c* above). Make a note of the position associated with the newly determined guide arm. The misplaced lug was on a bar having its other lug in this newly found position.

(2) Move any lug from the noneffective position to the position noted in *c* above, provided the other lug on the bar selected is in the position just determined in (1) above. The message can then be deciphered.

g. If the garbled text shows that some of the incorrect letters immediately precede, and others immediately follow, the correct letters in the alphabet ("Type 3 error," par. 36*m*), find the drum position causing the incorrect letters which immediately precede the correct letters in the normal alphabet by the procedure given in *a*, *b*, and *c* above. This position contained an extra lug on the enciphering operator's converter. By the same procedure, find the drum position causing the incorrect letters which immediately follow the correct letters in the normal alphabet. The extra lug was taken from this position. After determining the two positions concerned, move a lug accordingly. The lug at fault is likely to be on a bar with another effective lug.

APPENDIX V

REASON FOR USE OF RANDOM INDICATORS

1. Danger of a Repeated Indicator

a. The most serious fault occurring in use of Converter M–209–(*) is the re-use of indicators, either for two encipherments of the same message or for two different messages. The chances of this fault occurring are negligible *if each operator selects a random message indicator each time he enciphers a message or message part*. When the same indicators are used for two different messages enciphered in the same pin and lug setting, those messages may be read by the enemy. The process by which they are read is illustrated below. By the same procedure, a message which is *re-enciphered with the same indicators* (and the same pin and lug setting) as used for its first version may be read.

b. Suppose an operator has enciphered the following two messages with the same indicators:

Message 1 TTHVL UIHVC OESRM IUDPG
HTPVS VXWPE TLMIV YDSCV . . .

Message 2 TTHVL UIHVC HOUWG AMAUK
TIAGR HHBBN SJDGF LUOOW . . .

(1) The rotors were alined exactly the same for the first letter of message 1 and the first letter of message 2; therefore, whatever number of spaces the type-wheel assembly turned to encipher the first letter of message 1, it turned an equal number of spaces to encipher the first letter of message 2. Likewise the rotors were alined exactly the same for enciphering the second letter of message 1 as for the second letter of message 2, and therefore the type-wheel assembly turned the same number of spaces for one of those letters as for the other. This same condition is true for the third letters of the text, the fourth letters, etc.

(2) The machine enciphers on the following principle:

(*a*) The plain-text alphabet is on the indicating disk and the cipher-text alphabet is on the type wheel. The two alphabets have a fixed relationship, shown below.

Indicating index

Plain text	AZYXWVUTSRQPONMLKJIHGFEDCB
Cipher text	STUVWXYZABCDEFGHIJKLMNOPQR

Print hammer

Direction alphabets move during operation

It will be noted that when a letter of the plain-text (upper) alphabet is alined at the indicating index, a letter seven positions to the right in the cipher (lower) alphabet is at the print hammer. This relationship is always true at the start of the encipherment of a letter. Then the type-wheel assembly is moved a number of positions, or perhaps none, when the drive knob is turned, and whatever letter of the cipher alphabet is in position against the print hammer is printed.

(*b*) Suppose the letter A is set at the indicating index to be enciphered; its cipher equivalent will depend entirely upon the number of spaces which the type-wheel assembly turns before printing. If the type-wheel assembly does not turn at all, Z on the type wheel will be against the print hammer and will therefore be printed as the cipher letter. (*The letter at the print hammer is the same as the first letter showing on the reproducing disk.*) If, on the other hand, the type-wheel assembly, is made to move one space, A will be at the print hammer and will therefore be the cipher letter; or if A is to be enciphered and the type-wheel assembly turns seven spaces, the letter G will have moved to the print hammer and will be printed as the cipher letter.

Note. The operator should follow the explanation with a converter at hand.

(*c*) As another example, if the operator will set R at the indicating index, he will find that the letter I

on the type wheel is at the print hammer (as indicated by the I showing on that reproducing disk). It can be seen therefore that if the type-wheel assembly does not move, an I will print as the cipher letter; or if the type-wheel assembly is moved three spaces (it turns toward the operator), the letter L is at the print hammer and will therefore be the cipher letter.

(3) It will be seen that if both the plain-text letter and its cipher letter are known, the exact number of spaces turned by the type-wheel assembly can be determined. For example, if it is known that R was set at the indicating index and N was printed as the cipher letter, then the type-wheel assembly has turned five spaces. Also, if it is known exactly how far the type-wheel assembly has moved, and the cipher letter is known, the cipher letter on the type-wheel can be set against the print hammer and the plain-text letter found by reversing the type-wheel assembly (turning it toward the rear of the machine) the proper number of spaces. For example, if the cipher letter is K and the type-wheel assembly is known to have turned 8 spaces, K is set at the print hammer by making K the first letter showing on the reproducing disk, then the type-wheel is turned back eight spaces and X is found to have been at the indicating index as the plain-text letter.

(4) Now consider the two cipher-text messages. By guessing the correct plain-text letter for the first

letter of message 1, the number of spaces the type-wheel was turned to produce the first cipher-text letter of message 1 (and also, therefore, the first cipher-text letter of message 2), can be determined. By setting the first cipher-text of message 2 at the print hammer and turning the type-wheel assembly back the same number of spaces, the first plain-text letter of message 2 can be determined. Similarly, by guessing the second plain-text letter of message 1, the second plain-text letter of message 2 may be found, etc. Now, if instead of guessing a single plain-text letter, a full correct word is guessed for message 1, the correct letters will be determined for each corresponding cipher letter of message 2.

(*a*) Suppose the first plain-text word of message 1 to be TWOZ (the letter Z represents an enciphered space). If this is correct, the letter T was set at the indicating index for the first letter of message 1. Setting T at the indicating index, G is found to be at the print hammer. The type-wheel assembly must have moved eight spaces for O to come to the print hammer. As has already been noted, the type-wheel assembly moved the same number of spaces for the first letter of message 2; the type-wheel assembly then has moved eight spaces and stopped with H at the print hammer. By setting H at the print hammer and reversing the type-wheel assembly eight spaces, it will be seen that A on the indicating disk is at the indicating index and was the first plain-text letter.

Message 1   O E S R M   I U D P G . . .
            T W O Z

Message 2   H O U W G   A M A U K . . .
            A ? ? ?

(*b*) For the second letter of message 1, W was set at the indicating index, which would put D at the print hammer. Since E was printed, the type-wheel assembly must have turned 1 space. For message 2 the letter O was printed at that point, and since the type-wheel assembly turned 1 space the print hammer must have started at N, and the letter at the indicating index therefore was M.

(*c*) By applying the same procedure to the third and fourth letters, it is found that the text of message 2 begins with AMMU, if message 1 begins with TWOZ. AMMU suggests AMMUNITION, and that word is filled in as the suspected first word of message 2.

(*d*) By the same reasoning as before, if the fifth plain-text letter of message 2 is N, the print hammer started at M, and the type-wheel assembly moved 20 spaces to G. Then for message 1 the type-wheel assembly is known to have stopped with M at the print hammer, after moving 20 spaces. The plain-text letter must therefore have been H. Continuation of this process proves that AMMUNITION is correct for message 2, since it yields logical plain text for message 1.

Message 1	TTHVL	UIHVC	OESRM TWOZH	IUDPG ALFTR
	HTPVS ACKS	VXWPE	TLMIV	YDSCV . . .
Message 2	TTHVL	UIHVC	HOUWG AMMUN	AMAUK I T I ON
	TIAGR	HHBBN	SJDGF	LUOOW . . .

(*e*) This process is followed until the complete text is read for both messages:

TWO HALFTRACKS NEEDED ASREPLA . . .
AMMUNITION ON HAND SUFFICIENT . . .

c. In the above illustration it is supposed that the first word of one message has been "guessed." In actual practice this "guessing" means that the cryptanalyst tries several words and discards each one which when placed in the message yields meaningless letters as "plain text" of the other message. Only the right word, when placed in the right message, yields a "good" word for the other message. Guessing a correct word is easier than may appear at first glance, and there are several short cuts in the method of completing solutions which are too detailed to be explained here. Any word which is known to be somewhere in one of the messages will serve the same purpose as a beginning word, although an hour or two may be required in finding its exact position.

d. IT SHOULD BE EMPHASIZED THAT THE ABOVE PROCEDURE CAN BE APPLIED ONLY WHEN A MESSAGE INDICATOR IS RE-USED. It is therefore important that operators follow the rules regarding selection of indicators.

APPENDIX VI

REFERENCES

1. Army Regulations

AR 380–5.

2. War Department Supply Catalogs

SIG 1 and 2, Introduction and Index (to the Signal Supply Catalog).

SIG 3, List of Items for Troop Issue.

SIG 4–1, Allowances of Expendable Supplies for Tactical Organizations

SIG 4–2, Allowances of Expendable Supplies for Schools, Training Centers, and Boards.

3. Decontamination

TM 3–220, Decontamination.

4. Demolition

FM 5–25, Explosives and Demolitions.

5. Other Publications

FM 21–6, List and Index of War Department Publications.

FM 24–17, Signal Center and Message Center Procedure.

TM 11–469, Communication Security.

TM 38–650, Basic Maintenance Manual.

6. Forms

Army Air Forces Form 54 (Unsatisfactory Report).

WD AGO Form 468 (Unsatisfactory Equipment Report).

7. List of Abbreviations

A	adjust
AG	Adjutant General
AGO	Adjutant General's Office
APO	Army Post Office
AR	Army Regulation
ASF	Army Service Forces
Bn	battalion
C	clean
Co	company (commercial)

D.C.	District of Columbia
etc.	et cetera
F	feel
fig.	figure
FM	Field Manual
I	inspect
in.	inch, inches
ind.	indorsement
L	lubricate
lb	pound, pounds
mfg	manufacturing
No.	number
par.	paragraph
Phila	Philadelphia
pr	pair
reg	registry
Sig C	Signal Corps
SOI	Signal Operation Instructions
T	Tighten
TB	Technical Bulletin
TM	Technical Manual
TNT	trinitrotoluene
USA	United States Army
WD	War Department

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